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DETECTION AND CORRECTION OF HAZARD TREES IN WASHINGTON'S RECREATION AREAS

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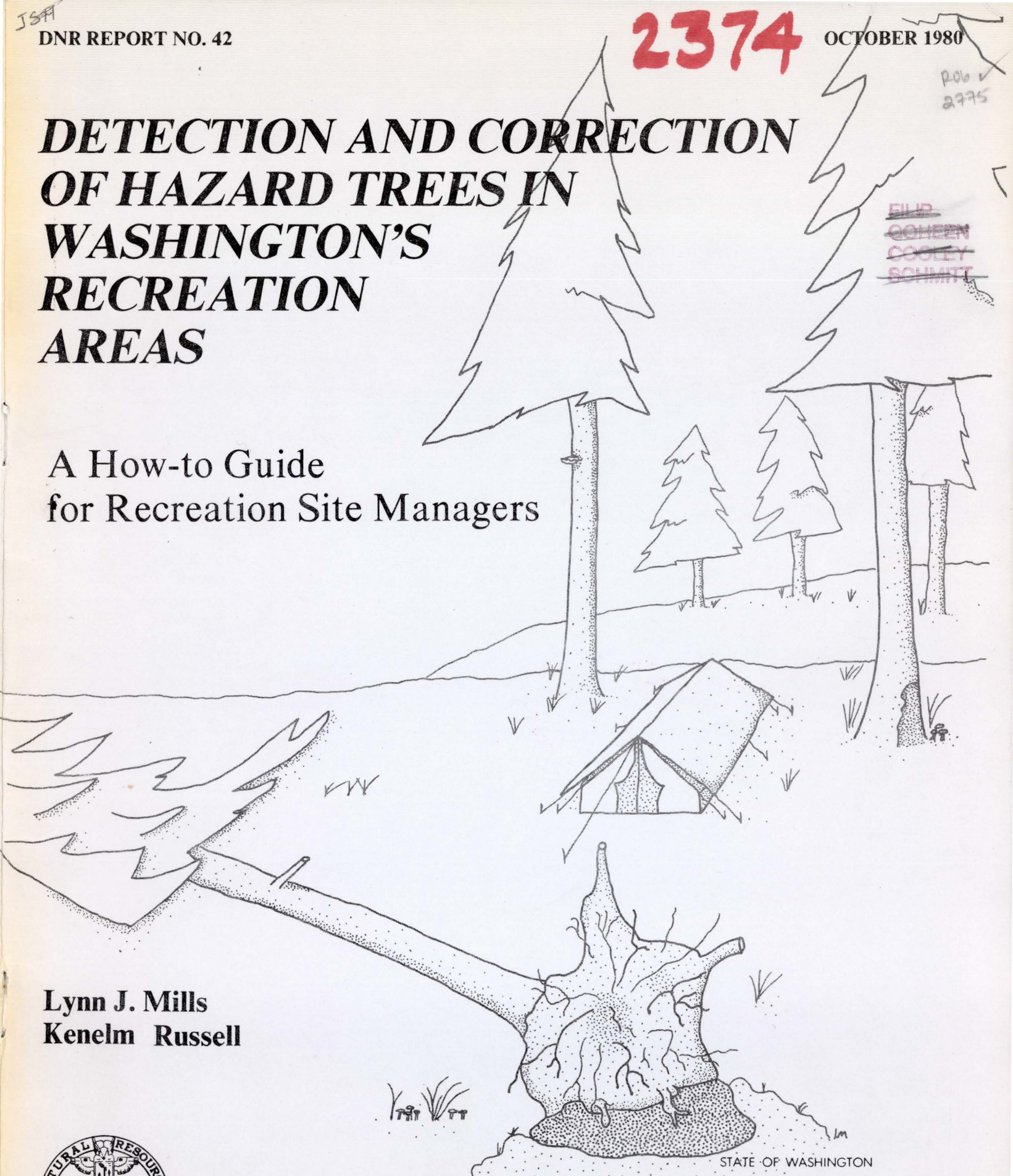
A How-to Guide for Recreation Site Managers



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Kenelm Russell

STATE OF WASHINGTON
Department of
Natural Resources
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A How-to Guide for Recreation Site Managers

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Abstract

Hazard trees are defective trees that may fail and harm people or property thus endangering public safety. Liability, should an accident occur, is also uncertain. To avert potential accidents, a system of checking and correcting defective trees is suggested. This report describes a hazard tree reduction program for Washington's recreation areas. Included is a system for annual inspections, a description of defects and potential hazards and a discussion on methods of correcting hazard trees.

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Introduction

What is a Hazard Tree?

A hazard tree contains some form of structural defect, a peculiar location or combination of both, giving it a high possibility of failing and causing personal injury or property damage. For a hazard to exist there must be a valuable target: buildings, cars, or people within close proximity of the tree. A rotten tree deep in the forest and away from people is not a hazard because there is no target. However, a rotten tree near a viewpoint, interpretive sign or campsite is a hazard since people have been invited there.

Hazard Tree Reduction Program

A hazard tree reduction program is a systematic method for correcting tree hazards in order to prevent damage to persons or property. The main purpose is to provide recreation site employees with methods of identifying hazard trees and ways of correcting them. Recreation sites should have annual inspections and special inspections after storms to examine all potential hazard trees.

Legal and Safety Obligations

During the past several decades there have been millions of dollars worth of property damage nationwide in local, state, and national parks due to tree failures (Gaidula, 1973). There have been numerous injuries and even fatalities resulting from tree failures.

Liability is an important issue. According to the **Federal Tort Claim Act of 1946,** the federal government could be liable for any loss of property, personal injury, or death which was caused by the negligence of any government employee acting within the scope of a particular job (Menefee, 1973). This act waived the long time doctrine of sovereign immunity which, in simple words, said an individual could not sue the government.

Many states now have statutes patterned after the Federal Tort Claims Act. In Washington, as a general rule, under RCW 4.92.090 an individual may sue the state on the same grounds that a private party may be sued. Washington does, however, have a **"Recreational Landowner's Immunity Statute",** RCW 4.24.200, 210, which limits the liability of public and private landowners from public recreational users. This law is intended to encourage public and private landowners to open their lands to the public without fear of being sued for damages suffered by recreational users. Under this Washington statute, public and private landowners could be liable to recreational users for:

(1) Injuries resulting from the landowner's negligence in areas where the landowner charges a fee for recreational use
(2) Intentional injuries by the landowner to the recreational users
(3) Injuries resulting from unposted, known, dangerous, artificial, latent conditions
(4) Injuries to small children resulting from attractive nuisances

The **Washington Immunity Statute** should provide recreation site owners protection from liability for natural hazards. However, Department of Natural Resources attorneys have advised their management that enough "loopholes" exist in the statute to justify a hazard tree rating program as one further means of limiting liability. Department attorneys recommend that a program be implemented in all areas where a fee is charged, where a site is formally developed, or where signs are posted inviting the public to use a particular place (Handy, 1980). In these places, the Department is indicating that the area is safe for public use.

Failure to carry out periodic inspections and to correct reasonably detectible tree hazards could leave recreation site owners open to costly lawsuits in the event of a serious accident.

The expense of a hazard tree reduction program, i.e., the time spent on inspections and treatment, can be easily justified as a good insurance policy. Lawsuits and awards can be costly and time consuming, therefore annual inspections and corrections will result in safer recreational sites and potentially lower legal costs.

Examples of Tree Failures and Damage

Following are examples of tree hazard problems.

In August, 1976, in a campground at Millersylvania State Park, a decayed tree fell across a Volkswagen bus with a camper and canoe on top. No one was injured but there was substantial property damage. Most was covered by the owner's auto policy and a claim was sought against the state for the balance. The state was found negligent and the courts awarded $716 to the owner of the Volkswagen. Fortunately, this case did not involve injuries or fatalities and was relatively inexpensive to settle.

The second example involves a private recreation area in Washington where people purchase wooded plots of land to park their recreational vehicles. The recreational park's gravelly soil produced trees of poor vigor and rooting habit. During the Lincoln Day storm of 1979, a blast of wind rushed up the nearby river gorge into the recreation area, toppling trees in its path. Before the storm ended, 132 trailers and campers were damaged by falling trees and property loss was estimated at several million dollars. Trees blocked roads, water pipes were broken, and power lines were down. Property damage was covered by the lot owners' individual insurance policies.

Luckily, the storm occurred on a Monday night and the few people present managed to get out. One wonders what the outcome would have been had the storm been at 2:00 a.m. on a weekend or holiday when a large number of people were present.

In another accident during a 1977 windstorm, a mobile home near Nisqually in Thurston County, was demolished by a 38" DBH (diameter at breast height) cottonwood (Figure 1). The combination of wind and a hidden decay column caused the tree failure. The gusty wind blew the tree away from the trailer, but during a sudden lull, the tree whipped back, snapped off, and crushed the trailer.

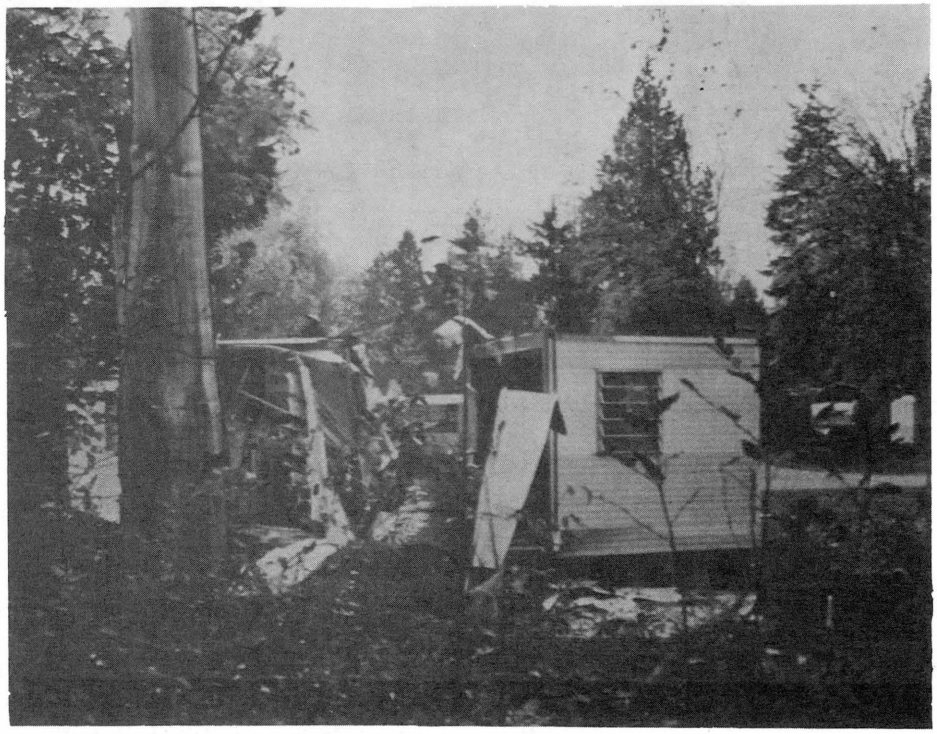


Figure 1 Demolished mobile home resulting from wind failure of a 38 inch diameter black cottonwood.

The accident occurred in the middle of the night and two women sleeping in the trailer were trapped. They had to be removed from the wreckage with metal cutting saws. Miraculously they were not injured, but this is not always the case as is shown in the next example.

In May 1975, at Sun Lakes State Park in Eastern Washington, a limb of a willow tree in a playground area failed during a windstorm. A five-year-old boy was struck on the head by the limb while playing on a slide near the tree. He suffered brain damage and still, after five years, requires medical attention.

The tree had a split crotch which had been pulled together with a cable about 20 years earlier. The cable had been incorrectly wrapped around the main trunk of the tree instead of being properly secured with eyebolts. Over the years, the cable became ingrown and hidden, and the limb failed during the storm at a fracture resulting from the cabling. It was later found that the tree only had about one inch of sound wood around a column of hidden decay.

The state was found negligent in this incident. Two lawsuits have stemmed from this case: first, the parents have been awarded $50,000 for pain and anguish suffered from the incident; and second, still pending for trial, the father is asking $1,058,588 for injuries to his son.

It is sad this mistake ended tragically, but it emphasizes the importance of a **conscientious hazard tree reduction program.**

Inspections

A systematic inspection of each site should be carried out annually. All trees within falling distance of campsites, picnic sites, roadside viewpoints, monuments, buildings, parking lots, or any place where people congregate, should be examined. The best time to conduct an inspection is in the spring after trees have been exposed to winter storms and before heavy seasonal use. Additional inspections may be necessary after hardwoods have leafed out or after a severe summer storm.

An inspection should be conducted by a team of at least two people. Trees can then be viewed simultaneously from different perspectives and opinions concerning defects and treatment can be discussed.

Maintenance employees working in sites should be constantly alert for potential tree hazards. Potential problems must be reported immediately and proper warnings made until correction is completed.

Hazard Rating System

The seven point hazard rating system that follows is modeled after similar systems used in Olympic and Mt. Rainier National Parks. It accounts for four major factors:

(1) Tree failure probability within a given inspection period
(2) Probability of the tree striking a target
(3) Damage potential of failure
(4) The value of the target.

Each defective tree receives two numerical ratings, the first for the tree itself and the second for the target, should the tree fail. The sum of the two is the hazard rating for the tree and dictates when to take corrective action.

1. The first rating is based on chance of imminent failure. The tree is rated 1-3, with 3 highest and 1 lowest failure probability. This value depends on the presence of defects that influence the structural soundness of the tree such as root rot, internal decay, broken branches, etc. An extra point may be added if the tree exhibits other defects in addition to structural problems such as a severe lean in a tree with butt rot. The highest possible rating then would be 4.

2. The second rating is based on the extent of damage or injury to the target, should the tree fail. The target is rated 1-3, with 3 the highest and 1 the lowest chance of doing extensive damage.

3. The sum of these two ratings is the hazard rating for the tree. The highest possible rate is 7 (Table 1).

For instance, during a campground inspection, an inspector sees a 24-inch DBH hemlock with a declining crown, punk knots, and fruiting bodies. Closer inspection reveals several large, unhealed wounds on the trunk. Drilling into the tree indicates a living shell thickness of only three inches.

If the tree fails, it could fall into two campsites or crush an interpretive sign. The campsites are in use continually during the summer and most weekends in the spring and fall. The prevailing wind is westerly, and toward the direction of the campsites.

The tree rates 3 according to the hazard tree rating system, because it is unsafe and could fail at anytime. The target rates 3 also, because it is a heavily used area. The tree could do substantial damage no matter which direction it fell. The total rating of 6 indicates either tree or target removal. In this case, the tree should probably be removed since the alternative would be to move two campsites and an interpretive sign. The decision might be different, however, if the removal of that tree would be detrimental to remaining trees.

Table 1 Recommended Corrective Action for Given Hazard Ratings

Rating	Degree of Hazard	Action
2-3	Low	Monitor—do not remove.
4-5	Moderate	Monitor tree for another year; or remove tree or target.
6-7	High	Remove tree or target.

Influencing Factors of Tree Failure

The degree of hazard depends on type, size, and location of the defect; tree species and age; prevailing wind patterns; and the target. Before visiting the site, past reports and previous problems should be reviewed. Different tree species are prone to certain diseases and defects. Prior study and a general idea of what to look for ahead of time is helpful. For example, dead larch is very brittle so branch breakage could be observed. When laminated or Armillaria root rots are known to be in the area, careful attention should be paid to the roots of conifers.

Defect—Degree of hazard depends largely on type, size and location of defects. Some defects, such as root rot, loosened roots, or severe decay in the bole present a higher and more immediate hazard. Dead tops on conifers or cankers on branches allow more time for correction.

Defects covering large areas of the tree such as extreme dwarf mistletoe brooming or a lightning scar spiraling the entire length of the tree are more serious than small wounds on the bole or a light dwarf mistletoe infection.

Defect location also is a factor. A large, dead or unhealthy looking branch hanging over a picnic table or a playground is more hazardous than one elsewhere since most branches fall straight down.

Conifers vs. Hardwoods—In conifers, the highest percentage of tree failure results from root and butt rot. Hardwoods also succumb to root and butt rot, and because of their branching habit, are susceptible to branch and crotch failure too. Internal decay is more likely to extend into the branches of hardwoods than conifers. Therefore, one should expect more breakage caused by decay in hardwood branches (Wagener, 1963).

Large conifer branches (Douglas fir) are prone to break without decay because they are very brittle. (See added discussion under weather.) Hardwoods are most likely to fail during the growing season because of the added weight of foliage and increased wind resistance. However, ice buildup on hardwoods is often a cause of winter failure. Conifers are most prone to winter failure because of the loading effects of snow and ice.

Age—The age of the stand may give some hints too. Old trees are more prone to decay problems than young trees. Wounds, hollows, or fungus fruiting bodies are good indicators. Wind could whip over an old, weakened tree much easier than a small tree. A young vigorous stand should usually have few problems unless damaged by animals or man. An exception is when a stand is opened to the wind by an adjacent clearcut. The result is increased windthrow. Root rot can be in a stand of any age and probably constitutes the greatest hidden danger.

Weather—There are numerous external factors that influence tree failure. Among these are poor drainage, construction, chemical injury, lightning and poor rooting base. However, weather is probably the one most important factor. Most tree failures involve trees weakened by some defect compounded by snow, ice, or especially wind. Three out of the four examples of tree failure described earlier involved weakened trees and strong wind. Occasionally even healthy trees fail in severe wind storms.

Because of the effect wind has on the incidence of tree failure, prevailing wind patterns should be noted in each site (Wagener, 1963). For example, a tree with loosened roots standing near a campsite is more dangerous when the prevailing wind blows in the direction of the campsite than when it blows in the opposite direction. In areas of year-round occupancy, snow and ice may play a larger role in tree or branch failure because of the added weight.

Tall Douglas fir with 2 to 4 inch diameter branches can be particularly hazardous during winds in excess of 45-50 miles per hour. The branches are very brittle and snap suddenly in the gusts. The broken ends are often sharp and could pierce a roof or camper top, not to mention damage to a tent and occupants. These branches are equally dangerous during wet snowstorms.

Wind speeds can be judged remarkably accurately using the motion of trees and other indicators. Table 2 is a windspeed chart that describes windspeeds and tree motion. This table can be very useful in predicting damage, planning for correction or warning occupants of parks of potential danger.

Soil type also plays an important role in general tree stability during bad storms. Heavy, clay soils with shallow impervious pans cause shallow root development making the tree more prone to windthrow in moderate to heavy storms. Gravelly cemented soils will cause shallow, pan-shaped root wads similar to clay soils. Sandy soils, on the other hand, allow a ball-shaped root wad to develop resulting in more windfirm trees.

Target—An important aspect to keep in mind while inspecting a site is the target. Safety of the target is a major reason for the inspection. A target is any person or property that would be injured or damaged as a result of tree failure. Potential target areas are those specifically set aside or developed for public use such as campgrounds, restrooms, picnic areas, playgrounds, interpretive signs, viewpoints, boat launches, parking areas, etc.

Certain target areas should be especially stressed during an inspection. Sites of year-round occupancy are exposed to winter storms when tree failure is most likely to occur. These areas should be looked at carefully. Chance of an accident increases as site use increases. Therefore, heavily used areas should be inspected before infrequently used areas. Areas where people can be taken unaware, such as campsites or restrooms, should be carefully inspected. A person on a picnic would be more likely to get out of the way of a falling tree or leave the site in a storm, than a sleeping person in a campsite. Playgrounds should always be carefully inspected.

When there is no target, there may be no hazard. For instance, a snag may stand near a recreation area, but not within falling distance of a target. Although it might fail sooner or later, it could be retained since it adds to the aesthetic or wildlife value of the area.

Table 2 Wind Speed Categories and Effects on Trees Keyed to Standard Weather Forecasts

Inland			Marine Forecast	
Effect Caused by Wind	**Description**	**Wind Speed (Mph)**	**Wind Speed (Knots)**	**Description**
Still	Calm	0		
Smoke Drifts	Light air	1-3		
Leaves rustle, wind felt on face	Light breeze	4-7	0-33 knot categories are not shown as they vary according to intensity of weather systems	
Leaves and small twigs move constantly, flag extended	Gentle breeze	8-12		
Raises dust and loose paper; twigs and thin branches move	Moderate breeze	12-18		
Small trees in leaf begin to sway	Fresh breeze	19-24		
Large branches move; power lines whistle	Strong wind	25-31		
Whole trees move. Needles and small branchlets 2-6 inches long fly in the air	Stiff wind or moderate gale	32-38		
Twigs break off trees. Conifer branches up to 3 feet long litter roads and ground	Stormy wind or fresh gale	39-46	33	Small craft[1]
Roofing blows off; large conifer branches break	Storm or strong gale	47-54	34-47	Gale
Trees uprooted	Heavy storm or whole gale	55-63	48-63	Storm
Widespread damage	Hurricane-like Hurricane	64-72 73-82	64 +	Hurricane

[1]This category may be issued at lower windspeeds due to weather system variability.

Source: Fairbridge, 1967

Modified to Northwest conditions by K. W. Russell

Inspection Procedure

When starting the inspection, plan your route through the site to include examination of all potential hazard trees. Gain an initial impression of the overall health of the stand before evaluating individuals. Walk around the periphery of the area looking in. Do not conduct hazard inspections from the road. Walk backwards to check tops of trees. Look at the stand from different angles to spot leaning trees. Place yourself in potential target areas of suspected tree failures. Imagine what might occur during storms.

Glance at all trees, but zero in on those with defects or problems. Once a trained eye is developed, problem trees can be picked out quickly. Make detailed records only of trees with defects. For example, an examination of Ipsut Creek campground at Mt. Rainier (10+ acres) revealed seven defective trees which were recorded.

Use binoculars to check tops of trees for fruiting bodies, dead branches, or dead tops. (See Appendix II for recommended equipment.) The blunt end of a hatchet or axe can be used to "sound" the tree for hollowness. It can also be used to scrape soil or bark when checking for root rot. When decay is present, a cordless drill with a long aircraft bit is often used (Appendix II). An increment borer can also be used to judge the amount of sound wood present but may be tiring when many holes are to be bored. Photos of defects may be helpful in documentation of hazard trees.

When a defective tree is found that warrants a rating, additional information should be recorded. The location of the tree is necessary for easy future reference. This is best determined by azimuth and distance from a prominent

and permanent reference point. Diameter, height and possibly age measurements should be taken. The general stand could be aged and large trees estimated. Age information will help to determine if the tree's growth rate is slowing.

When making corrective action decisions, a tree is sometimes borderline between monitor and remove. In the rating system a tree rated 5 may present this problem. In this case get a second opinion from another knowledgeable person in the area.

Do not hurry an inspection. It is well worth the time to do a careful job. If the inspection is hurried, a hazardous tree could be missed or a non hazardous tree could be removed.

Occasionally, tree removal becomes a sensitive subject. A hazardous tree or group of trees may be designated for removal but a park manager or citizen group may try to dispute this decision. An emotional issue is hard to fight. Be objective and get outside opinions. A frank but tactful discussion may be all that is necessary to demonstrate potential danger. If the manager will not be persuaded, relocation of the target may be the only choice.

When control work such as topping or tree removal is necessary, the people doing the work should know why these measures are necessary. Bad publicity can result if a crew were removing trees but could not explain why if asked by a member of the public.

Record Keeping

It is important that good records be kept of all inspections. A conscientious effort to identify and correct tree hazards without documentation is difficult to defend in a lawsuit following an accident. Records become valuable in court for both documenting the use of a hazard tree program and providing details about specific trees (Gaidula, 1973).

Records of every inspection can be kept by using a checklist form which lists all potential defects. (See Appendix I for sample form.) The form is designed to make sure the inspector records all potential tree hazards. The checklist of known defects alerts the inspector to dangers and minimizes missing important items. In addition it provides complete site information, yet is quick and simple to fill out.

The form should be completed for each recreation area to properly document that an official inspection was made. When no hazard trees are discovered, this is simply stated on the form for the record. Annual records provide invaluable historical tree information for future hazard inspections. For instance, a tree may have a defect that is not hazardous now, but may render it hazardous in the future. Subsequent inspection teams will be alerted to it at reevaluation time. In this way, trees with low hazard ratings are monitored from year to year.

Careful records are especially important for new personnel. New employees may not be familiar with corrective measures taken years earlier and will not have followed the slow decline of a particular tree. Good records of previous work will help them.

In the Sun Lakes example, the accident might have been avoided if records had existed showing that the tree had been cabled years earlier. The tree was apparently a hazard when cabled and new wood soon covered the evidence. Through the years the hidden decay worsened, but no one observed it.

Detection of Defects

Begin the evaluation by looking first at the top of the tree, then downward, ending finally with the roots. Note all defects or symptoms that indicate a hazardous condition exists (Figure 30).

Defect Categories

Dead Trees and Snags—Although snags may stand for years, they are unpredictable and may fall at any time (Figure 2). They should be regarded as potentially hazardous and rated along with live trees. Most recently killed conifers without root rot can remain in a structurally sound condition for up to 3 years. Dead hardwoods begin to lose branches earlier than conifers and will be a greater hazard.

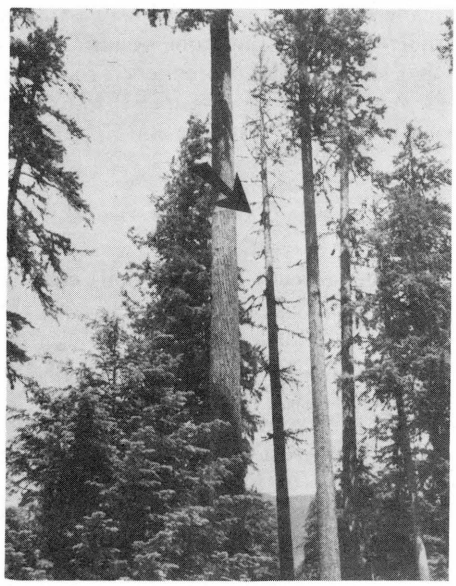


Figure 2 Dead tree directly above or within falling distance of a campsite. May have dangerous, heavy branches.

Dead Tops—Dead tops are potentially dangerous on all hardwoods and most conifers, especially true fir, spruce, and hemlock. Dead tops should be removed as soon as possible in hardwoods and as soon as practical in conifers. Dead conifer tops may not become a serious hazard for more than a year, providing the manager with leeway for corrective action (Figure 3).

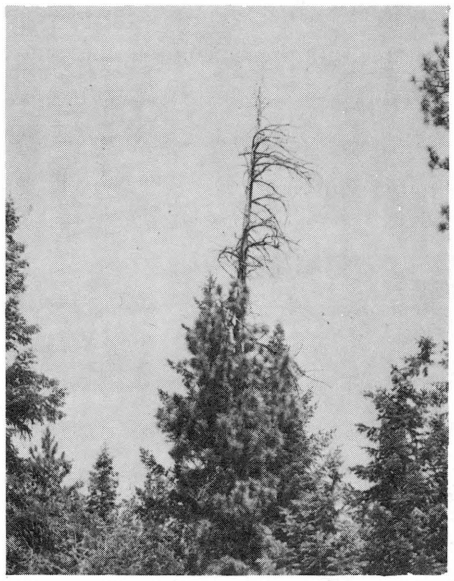


Figure 3 Dead tops should be removed as soon as practical.

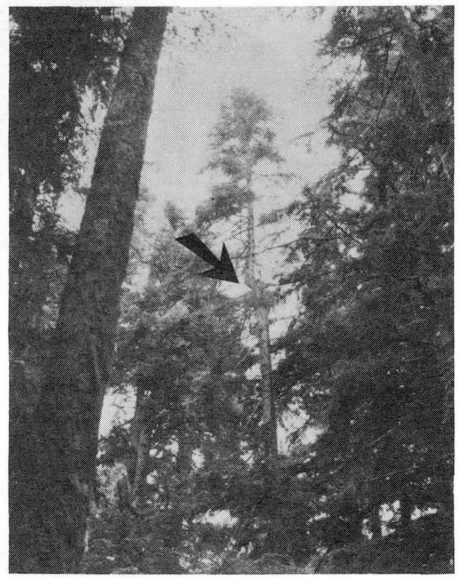


Figure 4 Volunteer tops are weaker than normal tops and may break in heavy ice or snow storms.

Volunteer Tops—Healthy volunteer tops that emerge as a result of the loss of a leader are not immediately hazardous (Figure 4). However, a fracture point may develop where the new leader takes off. Top breakage could occur years later from wind, heavy ice, or snow storms. Thus, they may pose a hazard primarily in areas of year-round occupancy or where people gather for winter sports.

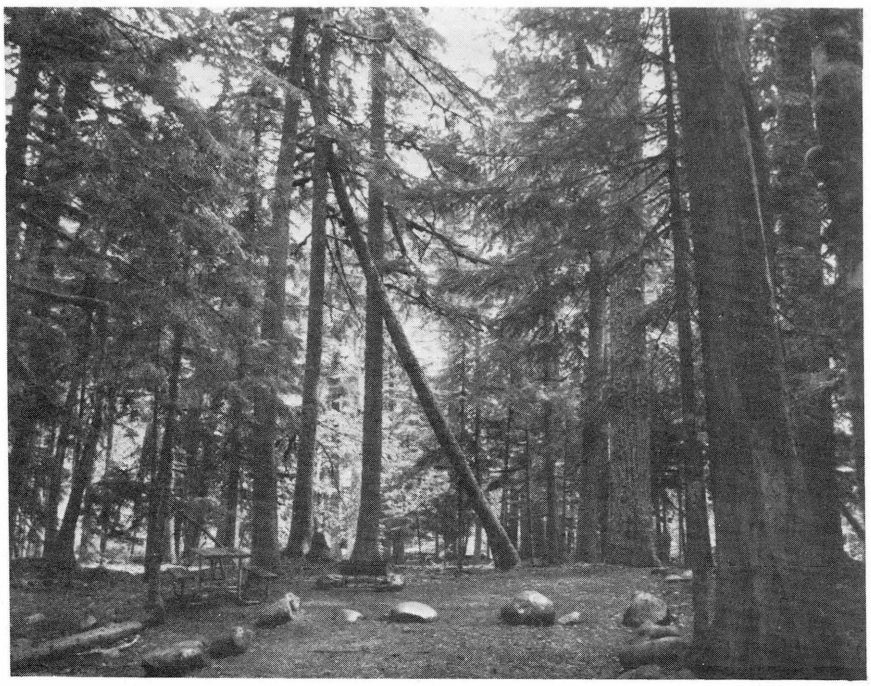
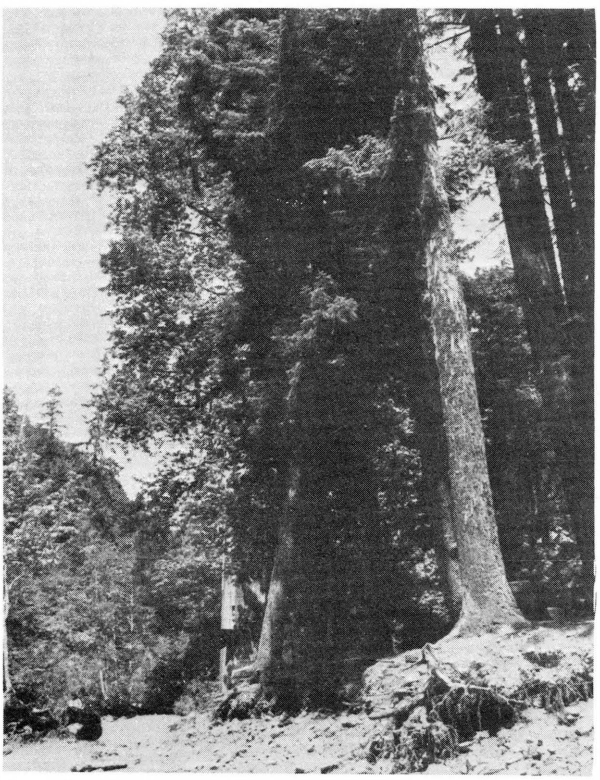


Figure 5 Leaning tree with weakened roots does not return to vertical.

Figure 6 Leaning trees in campground with roots undermined during floods.



Leaning Trees—Not all leaning trees are hazardous. Those that grow that way naturally and have sound wood may be desirable and aesthetic. In long-term leaners, the top tends to adjust vertically indicating a strong root system. Trees that lean because of weakened roots can be very hazardous (Figure 5). The top is not vertical in these trees.

Outside forces such as soil erosion, floods, heavy winds, root rots or nearby trees falling, bringing neighboring trees down with them may loosen the root systems (Figure 6). Trees sometimes are root pulled and severely damaged but settle back vertically as the wind subsides, only to blow over in the next storm. Edges of the root system near the drip line should be carefully checked for cracks or displaced soil which indicate movement. Young leaning trees do not pose a high hazard, but as they age and increase in mass, the likelihood of failure increases. Regard leaning trees with loosened roots as a potential hazard.

Figure 7 Dead branches, conifer.

Figure 8 Dead branches, hardwood.

Dead Branches—All dead branches are not necessarily hazardous because the lack of moisture and foliage makes them light (Hadfield and Filip, 1980). Hanging, broken, or cracked branches of large diameter must be removed (Figures 7 and 8). Dead branches and branch stubs provide entry for decay fungi and other microorganisms and should be pruned to promote rapid healing and add to the general health of the tree. Refer to page 23 for a general rule of thumb concerning when to prune dead branches and Figure 35 for correct pruning procedure.

Weak Forks and Split Crotches—Forked conifers have relatively little hazard unless the forks are long and heavy with the crotch at a right angle to the direction of the heaviest wind (Figure 9). If they fail, it is generally during wet snow storms. Split crotches generally occur on overmature hardwoods with large mass. They should be considered potentially dangerous.

Figure 9 Forked conifers may fail in heavy winds or wet snows.

Figure 10 Cankers weaken trees and permit microorganisms to enter.

Figure 11 Dwarf mistletoe brooms on ponderosa pine (left) and Douglas fir found only in Eastern Washington.

Frost Cracks—Frost cracks, more commonly found in Eastern Washington, form on trees with fairly sound wood and normally callus over the following growing season. Thus, they do not constitute a hazard unless they show evidence of opening frequently. An unhealed frost crack is a wound that may eventually allow decay to enter. It may take years for a hazardous condition to develop.

Cankers—Open cankers resulting from dwarf mistletoe swellings, insect attacks (pitch moths), or fungi not only weaken the tree but provide an excellent entrance for decay fungi (Figure 10). When present on the main trunk of a tree and when the width of the dead face exceeds half the circumference of the canker swelling, breakage is likely. In this case the tree should be considered hazardous (Wagener, 1963).

Dwarf Mistletoe—Dwarf mistletoe causes growth loss, vigor reduction, and mortality. Brooms and swellings on branches may not be serious hazards while alive, but after they die the branch weakens and may break. (Figures 11 and 12). Dead dwarf mistletoe brooms can weigh over 50 lbs. and often have many small, sharp branchlets which would cause considerable damage or injury upon failure. Once a dwarf mistletoe infection becomes established it will shower seeds on neighboring trees, spreading the infection. Dwarf mistletoe commonly occurs on Douglas fir, larch, ponderosa pine and lodgepole pine on the eastside of the state and both western and mountain hemlocks on the westside.

Removal of heavily infected trees and pruning lightly infected trees is usually recommended. This not only reduces the hazard, but stimulates tree vigor and reduces the amount of dwarf mistletoe in the recreation area.

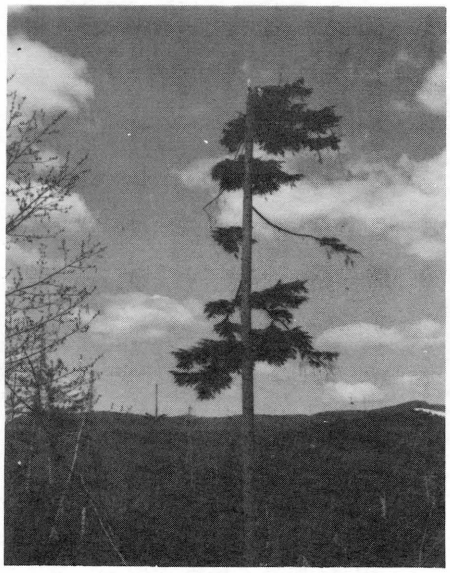


Figure 12 Dwarf mistletoe brooms on western hemlock found only in Western Washington.

The Hawksworth dwarf mistletoe rating (DMR) system is a fast and easy method that can be used to select trees to be removed. Trees infected with dwarf mistletoe are rated by dividing the live crown into thirds from top to bottom and assigning each third a numerical value:

0—No dwarf mistletoe

1—Less than half of the branches are infected

2—More than half of the branches are infected

The total of these three values is the tree DMR. The maximum DMR allowed becomes greater with increase in tree diameter (Table 3.):

Table 3 Maximum Allowable Dwarf Mistletoe Ratings by Diameter Class

DBH Class	Maximum Allowable DMR
1-2"	0
3-4"	1
5-6"	2
7"+	3

To judge if the tree should be removed, use the dwarf mistletoe rating system:

1. Divide the live crown into thirds and rate each third according to the amount of dwarf mistletoe present. For example, an infected tree might have: no branches infected in the top third, over half of the branches infected in the middle third, and less than half the branches infected in the bottom third. This rates 0, 2 and 1, respectively.
2. The total of the three values equals the tree's DMR or 3.
3. Knowing the DMR and the DBH, check Table 3 to see if the tree should be removed.

The purpose of this rating system is to **reduce the spread** of dwarf mistletoe and stimulate tree vigor. Originally, it was developed for commercial timber as a method of reducing the parasite to a minimal level that allows good tree growth.

This same scheme works well in recreation areas in most cases. The one situation in which this system is not effective is in heavily infested areas. There are some areas in Eastern Washington that would have to be clearcut if the DMR system were closely adhered to. When this is the case, much more dwarf mistletoe must be tolerated. Pruning of dead branches and mistletoe brooms combined with other vigor stimulating measures such as watering or fertilizing are worth considering.

Branches to be pruned should be cut flush with the trunk. Do not cut off individual dwarf mistletoe plants; they will only resprout from the internal network of "roots". Prune all live branches up to and including the highest infected branch. Do not leave isolated branches that appear to be mistletoe free because they may have latent infections (Lightle and Hawksworth, 1973).

Dormant dwarf mistletoe infections on remaining trees may become a problem several years after pruning or tree removal. Follow-up pruning may be necessary.

Lightning Scars—Lightning can kill trees immediately or cause wounds. Lightning scars often spiral around the tree (Figure 13). They can be shallow or wide cracks that extend into the bark. Probability of failure increases with size and extent of the crack. Lightning scars also provide entrance to microorganisms and could indicate the presence of decay. Lightning can cause seemingly unexplainable group mortality over up to several acres when trees are attached to each other by root grafts. Lightning damage is most often found in mountainous areas and in Eastern Washington.

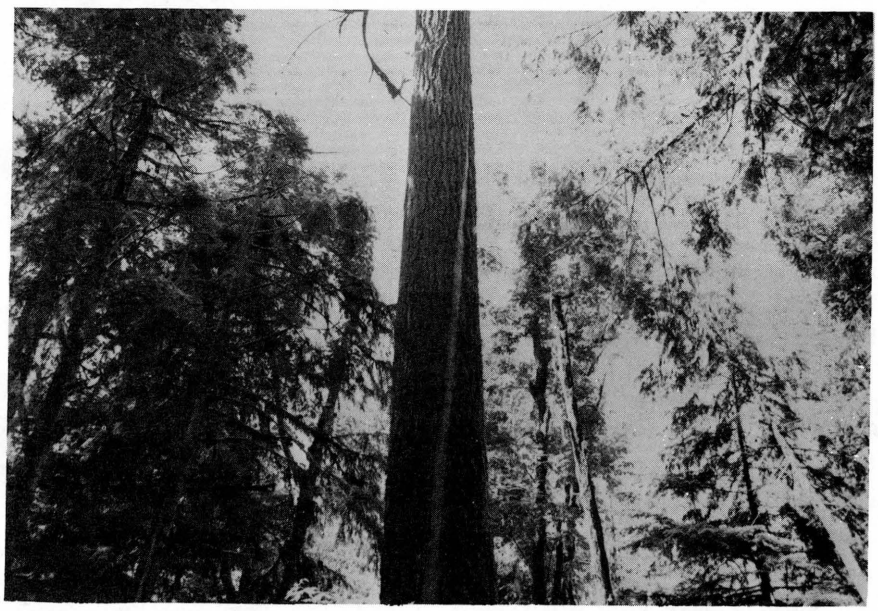


Figure 13 Lightning scar spiraling around this old growth Douglas fir.

Insect damage—In general, insect activity such as **bark beetle** damage usually means that the tree has been weakened by some other agent and is declining. This insect damage is not a hazard by itself but may indicate the presence of other problems, particularly root rot.

There are some insects, however, that can do extensive damage to limbs, boles, and tops of trees by boring into the interior and mining the wood out. If enough of the structural wood is mined out, tree failure is possible. This is a problem prevalent in Eastern Washington.

Cottonwoods and poplars are often attacked by **carpenter worms**. Look for worm holes in downed trees, cut wood, broken limbs, and stumps. These are indicators that carpenter worms are in the area. If carpenter worms become established, the stand age should be reduced. Trees with emergence holes in the bark should be pruned or removed depending on the severity of the infestation.

Carpenter ants often enter conifers or hardwoods that are already suffering from butt rot and speed along the eventual failure of the tree by mining the interior (Figure 26). Check trees for insect frass near the base of the tree.

The **sequoia pitch moth** may damage various pine species or Douglas fir by boring into the cambium, resulting in masses of pitch. Attacks are most common at the junction of limbs and bole or around injuries. Breakage can occur at affected areas.

Internal Decay—General indicators of the presence of internal decay in the butt or bole are:

Gradual **decline of crown**

Old wounds or **fire scars** (Figure 14)

Hollows, hollow centers (Figure 15)

Fruiting bodies on trunk or directly under tree (Figure 16)

Punk knots on trunk (Figure 17)

Unhealed broken **branch stubs** (Figure 18)

Cankers

Frost cracks

Slow rate of diameter growth in recent years.

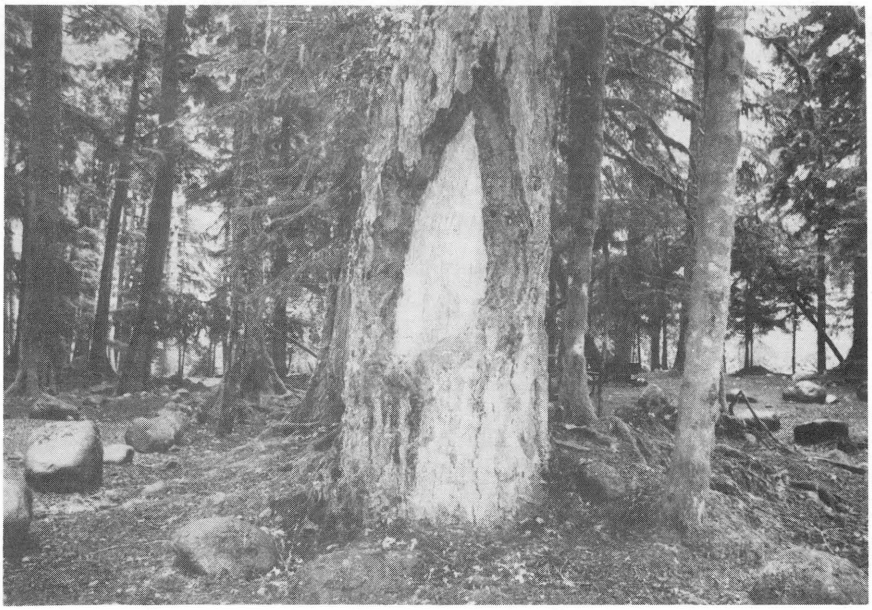
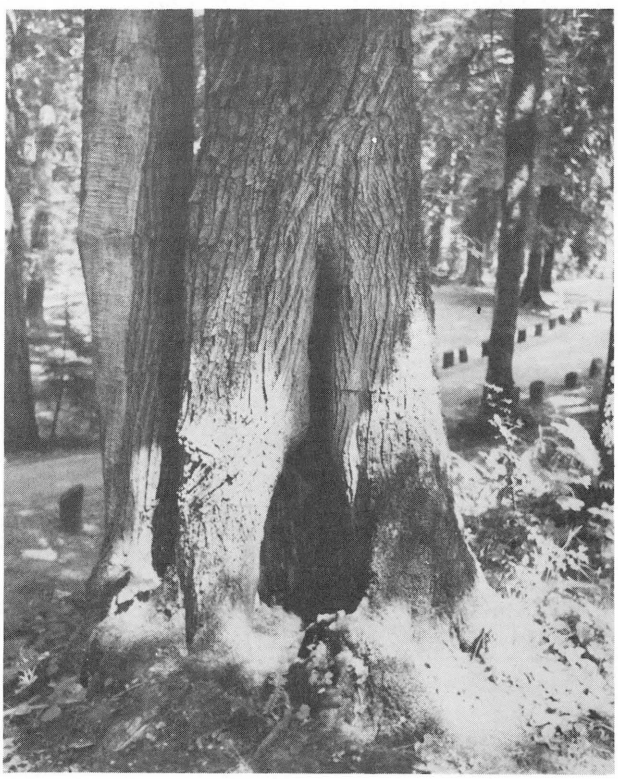


Figure 14 This wound permits entry for decay fungi causing extreme hazard in the next 20 years.

Figure 15 This hollow was probably similar to the wound in Figure 14, 30 years ago; a hazardous situation today.



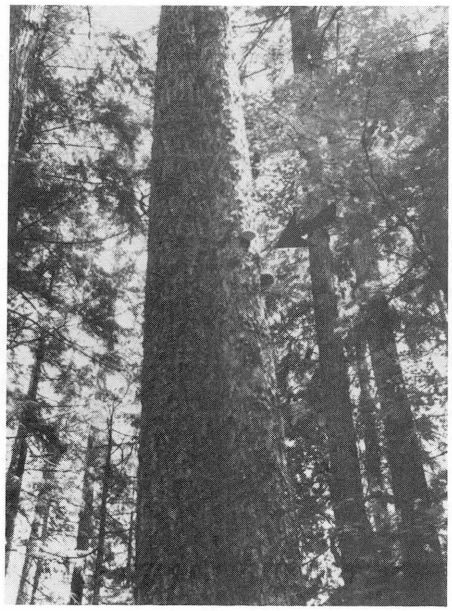
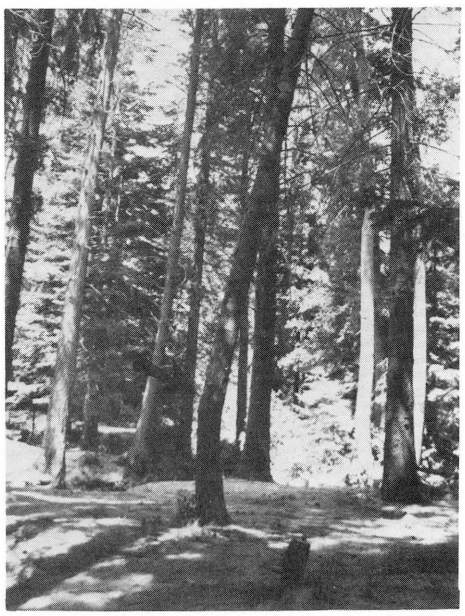


Figure 16 Conks or fruiting bodies of red ring rot, *Phellinus pini,* indicate substantial internal decay. Examine carefully for sound wood.

Figure 17 Numerous punk knots on this hemlock indicate extensive internal decay; removal recommended.

Figure 18 Dead branch stubs and branches open inner wood to decay organisms.

Figure 19 Tree failure due to red ring rot decay. Tree cracked at weakened point (arrow) and hung up on other trees in campground. Earlier inspection should have revealed conks.



These may occur singly or in combination. Presence of any of these indicators means the tree should be examined very carefully (Figure 19). A tree can have some trunk decay, but still be sound enough to not pose a hazard.

If the tree is obviously on the decline with fruiting bodies or a hollow containing decay, the tree is a hazard and removal should be considered. If the tree has one or two indicators, but seems to be fairly sound, drilling helps judge the amount of sound wood present. Drill into the tree with a cordless drill (See Appendix II) and observe changes in resistance. Healthy wood yields firm shavings and decayed wood yields powdery structureless shavings. An increment borer may also be used for this.

A general rule of thumb is that most trees can have up to 30% strength loss without affecting safety. This translates to about 70% loss in diameter inside the bark if uncomplicated by other defects.

Table 4 shows the minimum thickness of sound wood allowable around a column of decay for a given tree diameter. Any shell thickness less than that shown in the table would indicate an unsafe tree.

Table 4 Minimum Living Shell Thickness For Safe Tree

Diameter of Tree	Thickness of Sound Wood	Diameter of Tree	Thickness of Sound Wood
Inches	Inches	Inches	Inches
16	2.5	44	6.5
20	3.0	48	7.0
24	3.5	52	8.0
28	4.0	56	8.5
32	4.5	60	9.0
36	5.5	64	9.5
40	6.0	68	10.0

Source: Wagener, 1963

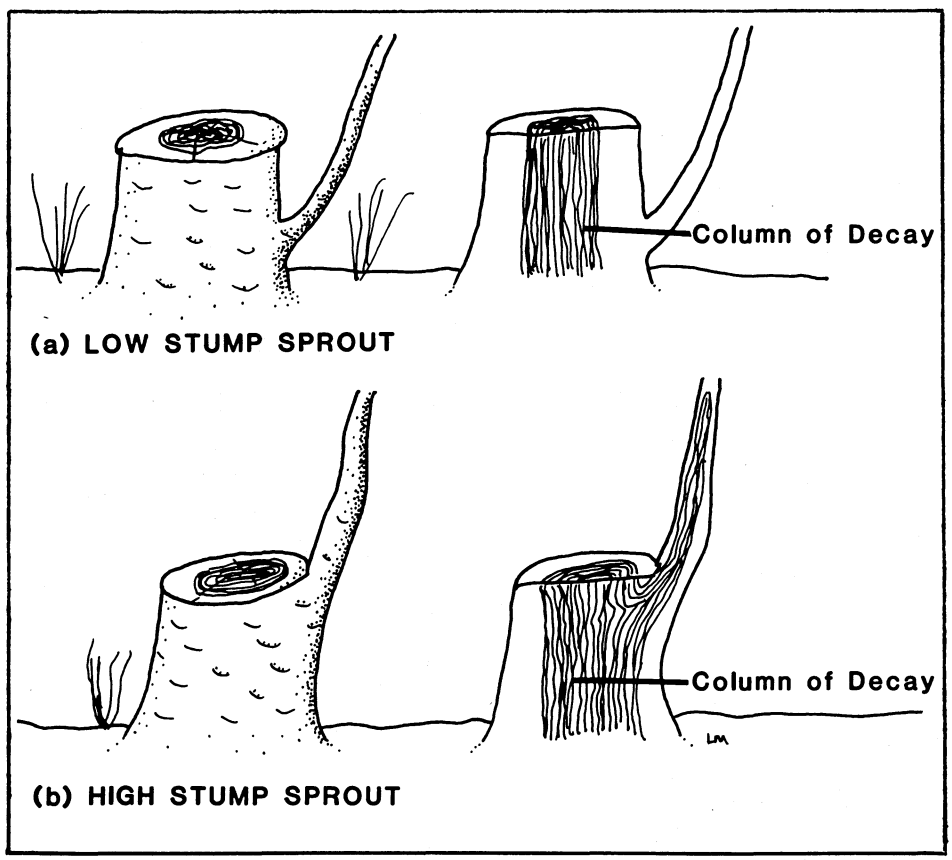


Figure 20 *(a)* Low stump sprouts are less likely to contract decay from parent stump. *(b)* High stump sprouts are more decay prone.

The condition of the main branches in hardwoods is more critical than the condition of the trunk. Trunk failures are rare in hardwoods (excluding butt and root failures). Exceptions are the weaker woods such as cottonwoods (Wagener, 1963).

After logging, many hardwoods form stump sprouts. Trees of stump origin are often affected by decay from the parent stump and if large, should be checked for decay. Generally, sprouts formed from large stumps as opposed to small stumps, and sprouts originating high on the stump rather than near the base are more prone to contracting decay from the parent stump. Stems forming from the base of the stump and below ground level are probably least likely to decay (Figure 20).

With forked stems in hardwoods and conifers, the removal of one will usually lead to entry of decay in the other. This is especially true when the fork is above ground or when the stems are three inches in diameter or greater (Figure 21). When considering corrective treatment of a forked tree, remove both stems or none. Do not leave just one stem because it has a high likelihood of becoming decayed (Peace, 1962).

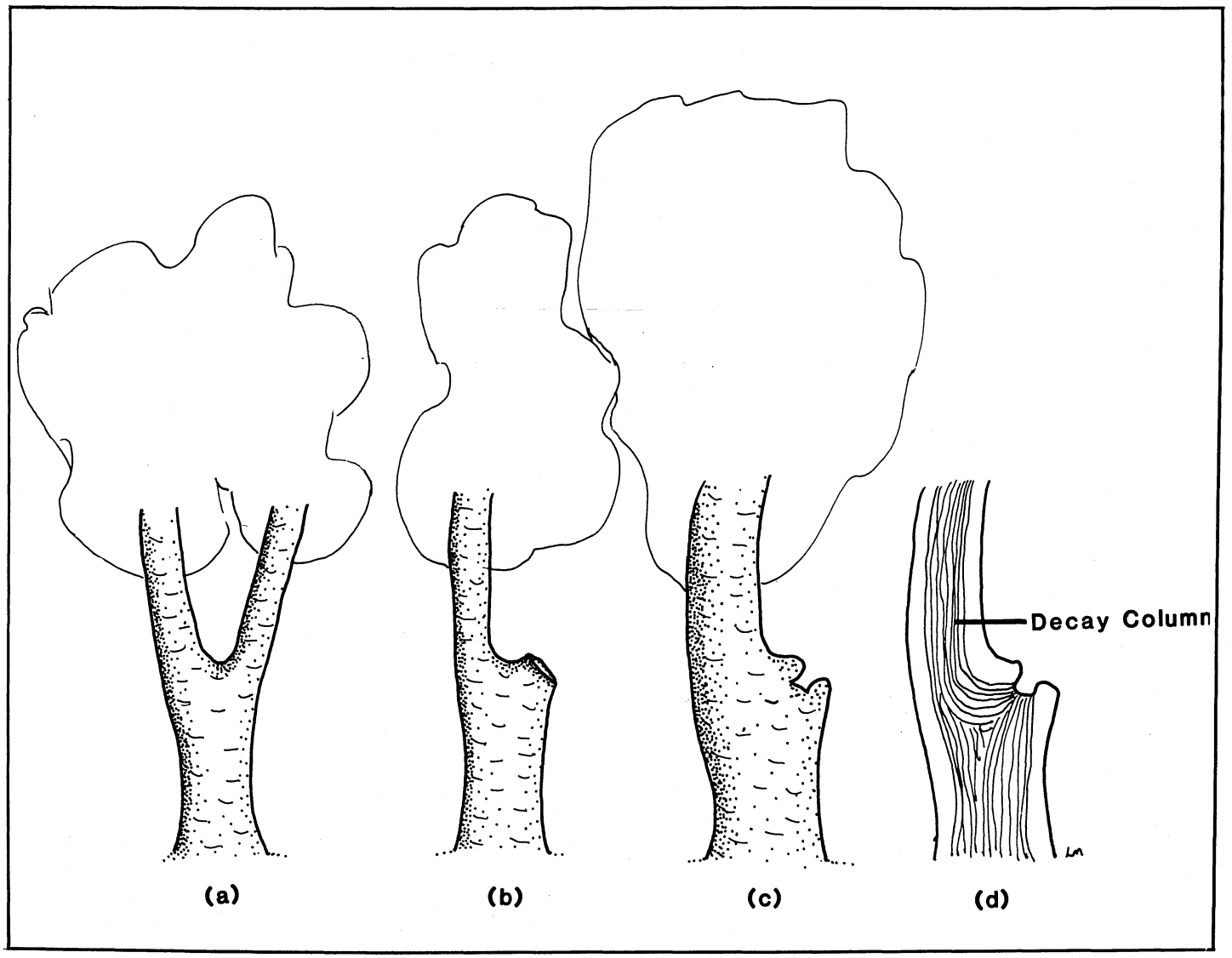


Figure 21 Removal of one stem usually leads to the decay of the other. *(a)* Forked stem, *(b)* removal of one stem, *(c)* the same tree years later, and *(d)* longitudinal section of *(c)*. Decay enters through wound and extends into remaining stem.

Root Rots—Root rots are the most important and dangerous cause of tree failure in the Pacific Northwest. They can cause serious damage because the whole tree fails rather than just part of it. Trees with root rot pose a serious threat to the unwary because roots can rot away, then the tree or a group of trees fails during a windstorm without showing obvious prior signs. Root defects are difficult to detect because they are hidden. Several outward symptoms and signs can be helpful in diagnosing root rots:

- **Poor growth** in recent years (Figure 22)
- **Crown decline**—thinning and chlorosis
- **Distress cone crop** in conifers
- **Slow decline** of tree, revealed by flattening top and poor vigor
- **Fruiting bodies** on base of tree or in soil under tree
- **Resinosus**—resin or pitch soaked bark and soil around base (Figure 23)
- **Wet looking bark** at base of tree
- **Broken rotted roots** (Figure 24)
- **Windthrow** of surrounding trees
- **Fungus mycelium** growing on roots or just under the surface (Figure 25)

Once the roots have been destroyed and killed, the tree will be on a progressive downswing which leaves it open to insects or other agents (Figure 26). Root rot affects trees by destroying the food and water transportation system. This is manifested by crown decline and poor growth. The supporting root system also is destroyed which is where the danger lies.

Most root rot spreads to other trees by root grafts or root contact which causes other trees in the vicinity to become infected even after the originally infected tree has been removed. Thus root rot centers, revealed by circular patches of dead and dying trees, often appear in a forest. Consequently, it is important to consider tree groups, not just single trees when dealing with root rot. Trees with root rot are the most serious hazard a recreation area can have and should be removed immediately.

A description of important root rots in Washington follows.

Figure 22 Poor growth and downed trees creating circular openings in a stand indicate the presence of root rot.

Armillaria root rot is caused by *Armillaria mellea* (Vahl. ex Fr.) Karst. It may infect both hardwoods and conifers on both sides of the state. Its distinguishing characteristics are heavy pitching around the base and in the soil; water soaked bark; thick, white mats of mycelium under the bark of the lower trunk or roots; and large, brown strings, or rhizomorphs, under the bark or in the soil. The fruiting body of this fungus is a light brown, gilled mushroom found at the base of infected trees or under the bark.

Figure 23 Resin soaking (resinosus) at the base of a tree is often a root rot indicator.

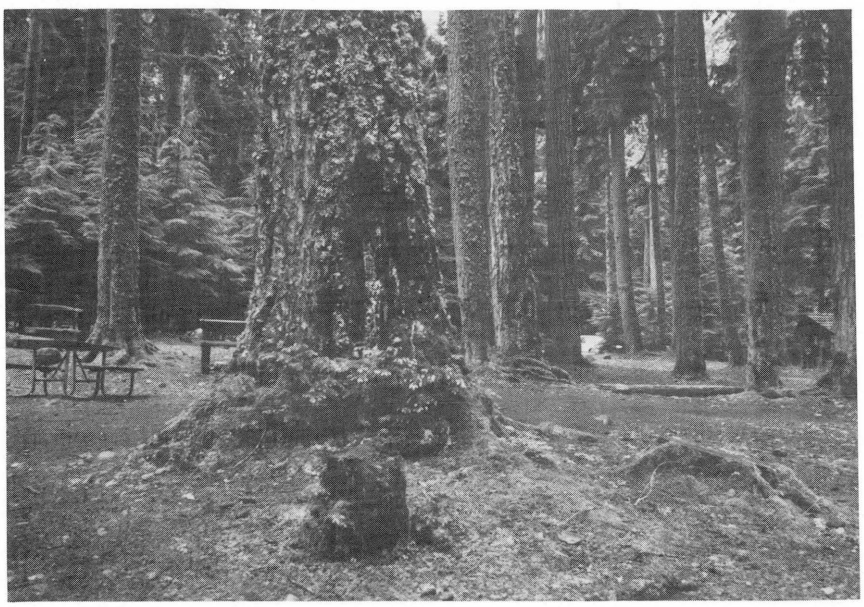


Figure 24 Broken, rotted butt and roots caused by laminated root rot. Rotted wood looks laminated and separates at the growth rings.

Laminated root rot is caused by *Phellinus weirii* (Murr.) Gills. and is found on conifers throughout Washington. Its main host is Douglas fir. It can be identified by the presence of buff to gray colored mycelium on root surfaces and red, setal hyphae in decayed wood. The setal hyphae can be seen individually with the aid of a hand lens and look like reddish "whiskers", or collectively as tufted cinnamon colored hairs. Other characteristics of this disease are resin soaked soil and decayed wood that appears laminated and separates at the growth rings.

Red-brown butt rot is caused by *Phaeolus (Polyporus)schweinitzii* (Fr.) Pat. which infects the roots and base of conifers throughout Washington. It is most often, but not always, found on older trees. The two distinguishing characteristics of this disease are the decay and the fruiting body. The advanced decay is a rusty, brown color and breaks into cubes. The velvety, brown fruiting bodies are either mushroom-like, growing on the ground above decayed roots, or bracket-like conks, attached to the base of the tree. The underside of the fruiting body has small pores.

The causal fungus of **Annosus root rot** is *Fomes annosus* (Fr.) Cke. It is prevalent on western hemlock on Washington's westside and may be found (but is not a serious problem), in Eastern Washington. A characteristic of this disease is the wet, white stringy rot with small flecks. It can be verified by incubating infected wood disks wrapped in moist paper for two weeks and observing the silvery-white club-like spore heads.

If Armillaria or laminated root rot is a problem in recreation areas, stump removal should be considered. Consult with the pathologist for complete methodology. Mechanical removal of infected stumps and their root systems is an effective method of reducing the spread of root rot to neighboring trees. Success depends on the amount of intact infected roots left in the soil after removal. It is best to break up roots still in the soil to stimulate rapid deterioration. If replanting follows, use nonsusceptible tree species if possible.

The only method of reducing red-brown root rot in an area is to remove infected and old, decadent trees. Conversion to a younger stand will protect against further outbreaks of the disease.

An effective control method for *Fomes annosus* is stump treatment with borax. Airborne spores of this fungus infect freshly cut stumps and start new infection centers. The disease then spreads to remaining trees through root grafts with the infected stump. By protecting freshly cut hemlocks stumps with dry borax, this airborne infection can be greatly reduced (Russell et al., 1973).

Figure 25 These white, fungus mycelial mats found beneath the bark on this ponderosa pine are characteristic of Armillaria root rot.

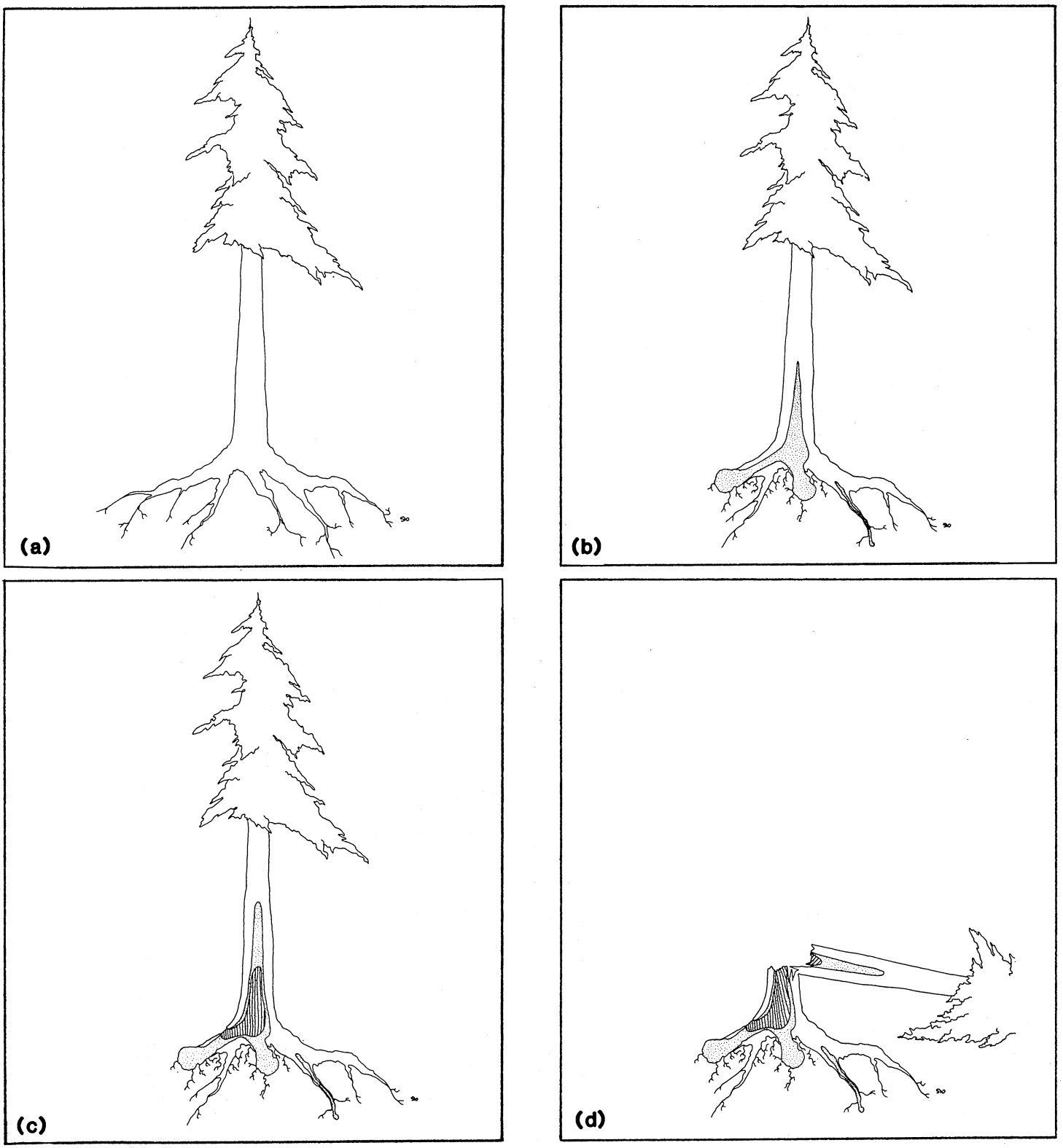


Figure 26 Schematic sequence showing slow, progressive failure of tree after red brown butt rot, *Phaeolus (Polyporus) schweinitzii*, infects a tree. *(a)* Healthy tree; *(b)* developing rot column, callusing, and loss of supporting roots; *(c)* carpenter ants enter after tree starts to decline; *(d)* failure at weakened point. (Drawings by Suzanne Hagle-Dubreuil, College of Forestry, Wildlife, and Range Sciences, University of Idaho.)

Construction Damage—Tree roots are often damaged by soil compaction, changes of grade, trenching, and other construction activities. Root damage can also occur when detergents, chemicals such as fuel oils or even hot water are dumped on tree roots. Reaction to root damage ranges from loss of vigor to death of the tree. Loss of vigor predisposes the tree to other maladies also.

Figure 27 Soil compaction in campground exposed roots to damage and decay.

Soil compaction adversely affects the growth of a tree (Figure 27). Growing roots turn away from compacted soil and roots present during compaction are damaged.

Soil compaction can be caused by heavy equipment and automobiles operating under trees. Motor bikes, horses and human traffic also severely compact soil in trail or campsite areas over a period of time.

When construction takes place, heavy equipment should be kept away from the drip line of trees. If possible, barriers (such as logs, bushes or fences) should be erected to keep heavy equipment and other vehicles or foot traffic away from trees. Forest litter under trees protects roots from damage and excessive soil temperature. Trees in campsites which have been heavily used will eventually show signs of decline. These campsites should be rehabilitated, moved, or closed for a few years.

Often during building construction or clearing for a recreation area the grade is either lowered or raised. Whenever the grade is changed around a tree, considerable injury to the roots can result.

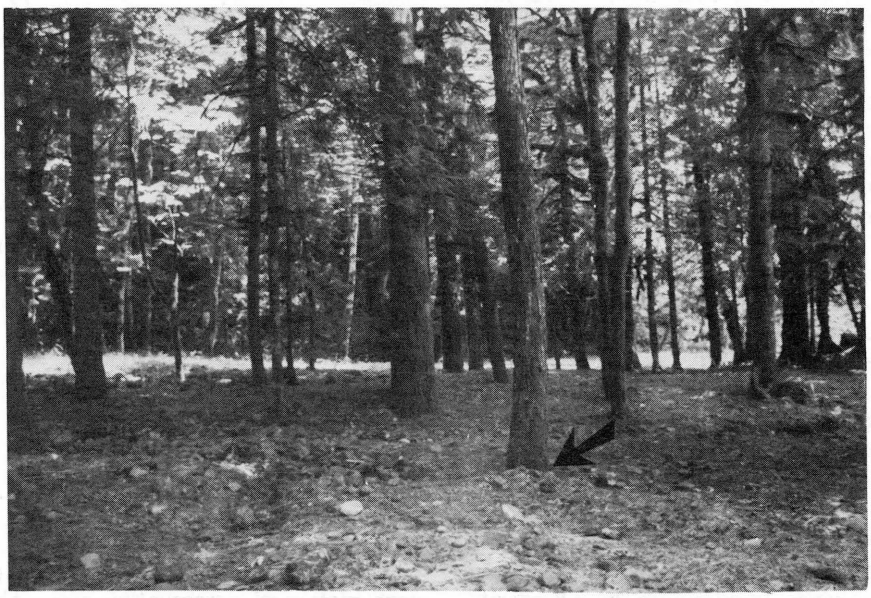


Figure 28 Soil build-up around trees from flooding river near campground suffocates roots which may kill the trees.

Raising the grade or back filling can suffocate the roots (Figure 28). Creating an impervious layer prevents roots from breathing. The tree will slowly become stressed. A tree can die as a direct result of fill, or it can become weakened and fall prey to another pest. Laying asphalt or concrete over a root system can suffocate a tree similar to raising the grade.

A backfilled tree is easy to detect. It looks like a "stove pipe" coming out of the ground. A normal tree will have a noticeable flair at the base of the tree.

Soil type will influence either the rapidity or severity of damage caused by backfilling. Clean gravelly soils of low compactibility are least damaging because of the relatively free movement of air and water. Clayey soils are the worst, suffocating trees in as little as one season because nearly all air and water is excluded.

Lowering the grade can lead to extensive root injury since most of the root system is in the top 18 inches of soil. Large and small roots are severed and extensive root wounding occurs, creating entry pathways for pathogens. Numerous cut roots will also render the tree dangerous in a wind. The usual symptoms are a general decline of the tree. The speed of appearance and severity of the symptoms depend on the amount of damage to the roots. If a tree suffers from change of grade, it may be helped by reshaping back to original contours. This combined with reestablishing vegetation may help the tree survive.

Trenching for sewer pipes or water pipes can cut many roots if done near trees. Damaged roots lead to decline of the tree. The best way to prevent this kind of damage is to drill or tunnel under the tree's roots or locate trenches as far from the tree as possible (Figure 29).

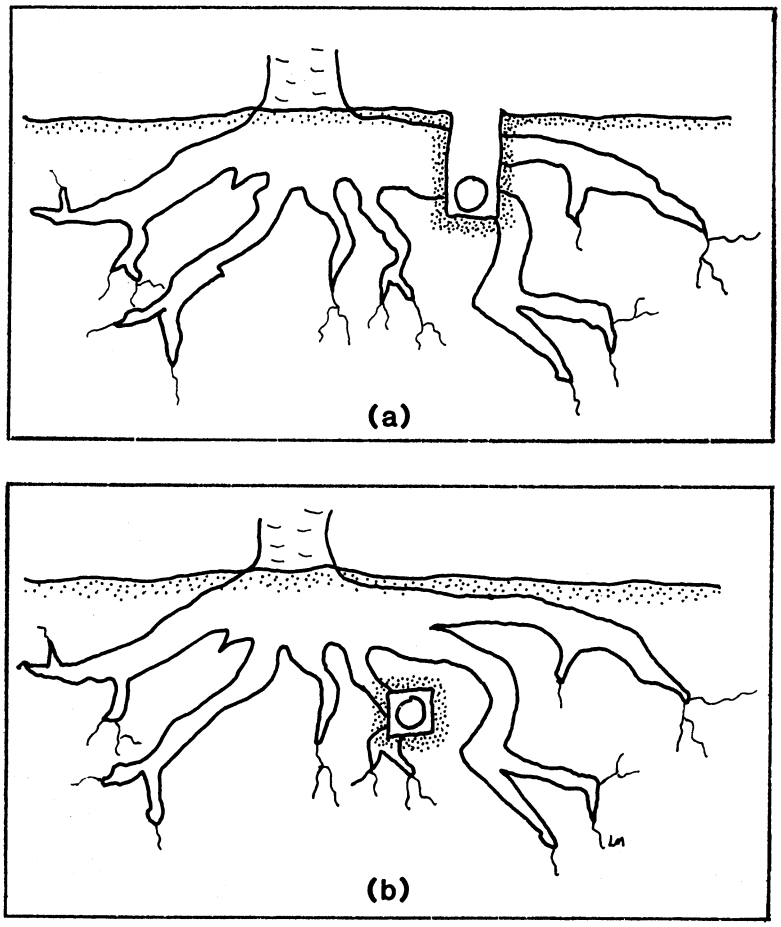


Figure 29 Root damage from trenching. *(a)* Extensive root injury occurs when trench cuts major roots. *(b)* Root injury minimized by tunneling, or moving trench elsewhere.

Changing water table caused by road construction, beaver activity, or any blockage of normal drainage, can cause root mortality and weakened stability. A road fill functions as a dam, restricting normal water movement in the soil. The water table rises and drowns the roots which need oxygen for survival. This type of injury usually takes time for full expression and may take several years to appear. Generally, when saturated soils are present, trees are more prone to windthrow because of the poor rooting base and root damage. Good engineering on culvert placement is a prerequisite to minimizing water table changes.

The only way to eliminate these kinds of injuries and their eventual effects is to **prevent** them. Once a tree has noticeably declined from a construction injury, limited corrective measures are available. For **root damaged trees,** restoring a balanced shoot:root ratio by pruning 20% of the crown back and applying a phosphate fertilizer will stimulate root growth (Tattar, 1978). Trees with these types of damage should receive special consideration at subsequent inspections because they are more susceptible to becoming hazard trees.

Changing vegetation often occurs during construction of a recreation area. This can be detrimental to remaining trees. Thinning and clearing tends to create increased wind action in the stand promoting windthrow of remaining trees. Opening shade tolerant trees to the sun will cause their ultimate decline. Removal of ground vegetation may cause the soil temperature to rise under remaining trees resulting in root damage and eventual decline.

Whenever tree removal is necessary around building sites or recreation areas, they should be removed in logical groupings. Remaining trees should also be left in groups to support each other. This **"Island Concept"** of tree removal will minimize damage to remaining trees from suddenly increased exposure to wind or sun. These damaging effects can also be minimized by gradual removal of trees over a period of years. This necessitates long-range planning before recreation sites are fully developed and can make a considerable difference in allowing remaining trees to gradually adjust to changing microclimate influences.

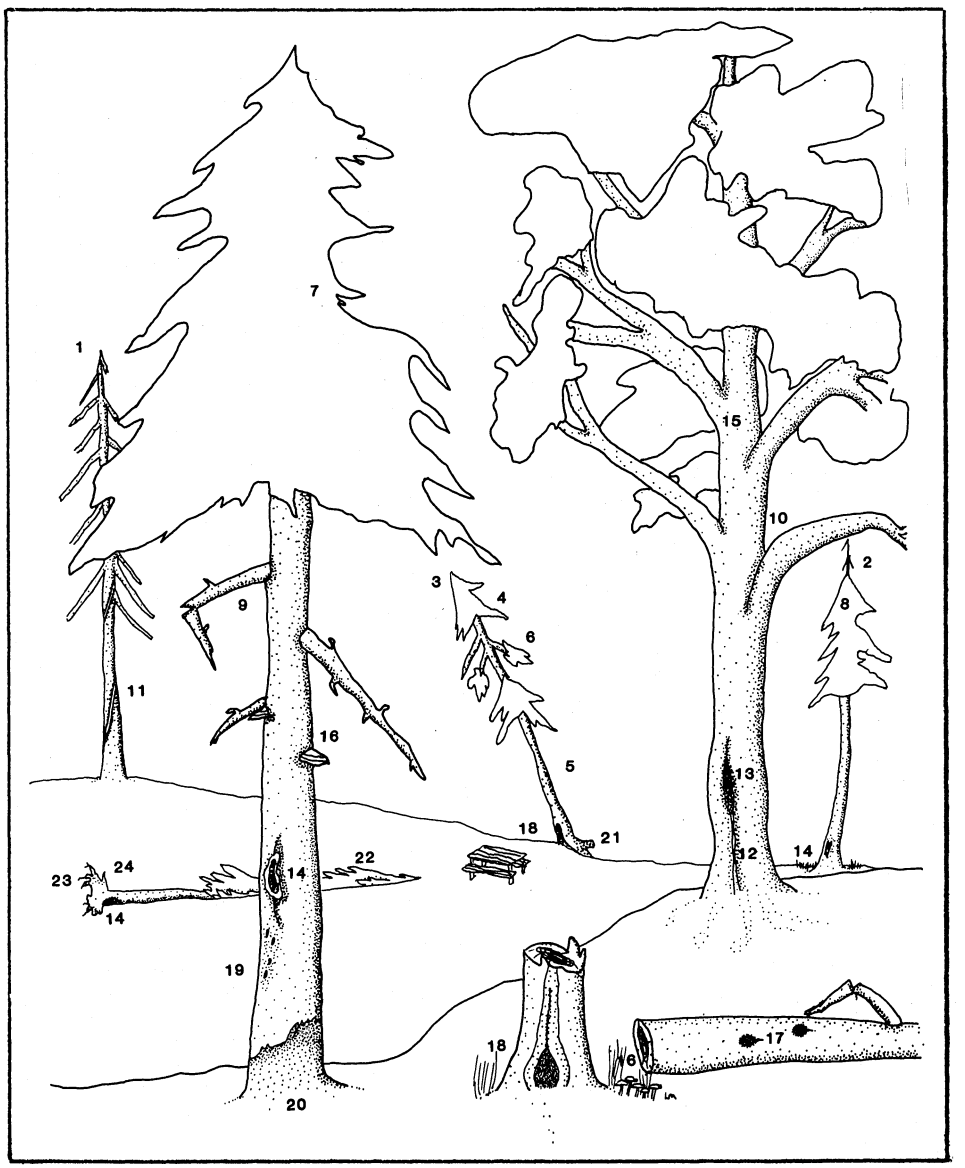


Figure 30 Identifying defects: Observe trees from top to bottom for the following defects. How many can you identify?

1 Dead tree
2 Dead top
3 Slow growth rate — general decline of the tree
4 Thinning, yellowing, or red crown
5 Leaning tree
6 Dwarf mistletoe brooms
7 Distress cone crop (unusually large numbers accompanied by thinning crown)
8 Foliar insect feeding
9 Large, dead or broken branches and branch stubs
10 Split crotch (hardwoods), weak fork (conifers)
11 Lightning scar
12 Frostcrack
13 Canker rot
14 Wound (trunk or roots)
15 Bark beetles
16 Fruiting bodies (conks) on trunk, branches, or around base of tree
17 Punk knots on trunk
18 Hollow
19 Resin soaking (resinosus) at base of tree and nearby soil
20 Wet looking bark at base of tree
21 Loosened roots (leaning tree)
22 Other downed trees in area with small root ball and rotted roots
23 Broken, rotten roots
24 Root insects

Correcting Living Hazard Trees

Once a hazard tree has been identified, the next step in the process is to find an acceptable way of correcting it. Each situation must be looked at individually and the impact on the whole area be considered. There are basically four options for treatment of hazardous trees:

- Target Removal
- Tree Removal
- Topping
- Pruning

Bracing or cabling a defective tree may be done, but should be reserved for unusual situations. An expert should be consulted for bracing or cabling.

Tree removal is not always the best solution. Once a tree is removed, it takes many years to replace it. An alternative to tree removal should always be considered first. Removal of a hazardous tree may create an opening which allows stronger wind action, which could affect remaining trees. Removal of too many trees may reduce the aesthetic quality of the recreation area to a point where people will not use the area.

Target Removal

A way of eliminating a hazard is by manipulating people or facilities out of target areas. This can be done by moving a campsite to a safer place or by converting an overnight camping facility to day use only.

Tree Removal

Sometimes tree removal is the only solution. If a tree is highly hazardous, suffering from such maladies as root rot or considerable decay, it must be removed as soon as possible. When tree removal is prescribed, it should be done with a minimum of damage to other trees. In some cases, tree removal will be so dangerous to the tree cutter that a professional logger should be called in.

Topping

Topping is recommended for conifers when dead or broken tops need to be removed. Tall conifers tend to catch the wind easily. Even healthy trees can blow down in a severe storm. Topping reduces the windage and the hazard without completely losing the aesthetic qualities of a tree. The cut top is often hidden from view. Topping, if done carefully and artistically, can result in a near normal shape. However, if done carelessly, the resulting effect will be similar to an old fashioned flat-top haircut (Figure 31). After the top is removed, reshape the remaining branches to give a nice form. This will require severe pruning which will fill in within two to three

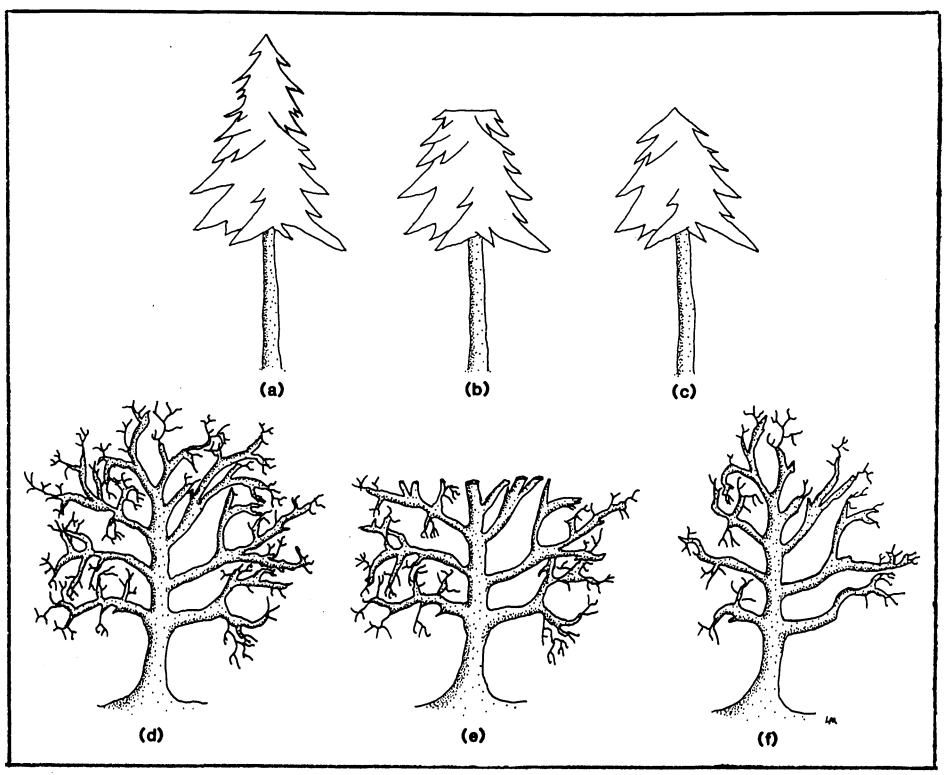


Figure 31 When conifers are topped, remaining branches can be reshaped. *(a)* Hazardous conifer that should be topped, *(b)* topped but poor form, *(c)* topped and reshaped. *(d)* Large hardwoods should not be topped. *(e)* Poor form, eventual decay, and continuing hazard results. *(f)* Pruning is the proper way to reduce the crown of a hardwood.

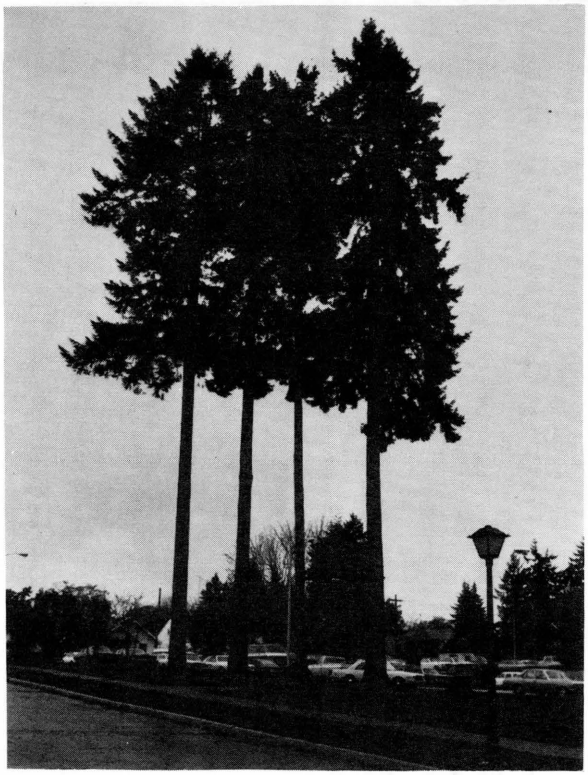


Figure 32 Douglas firs topped 17 years previously, have a safe, pleasing natural shape.

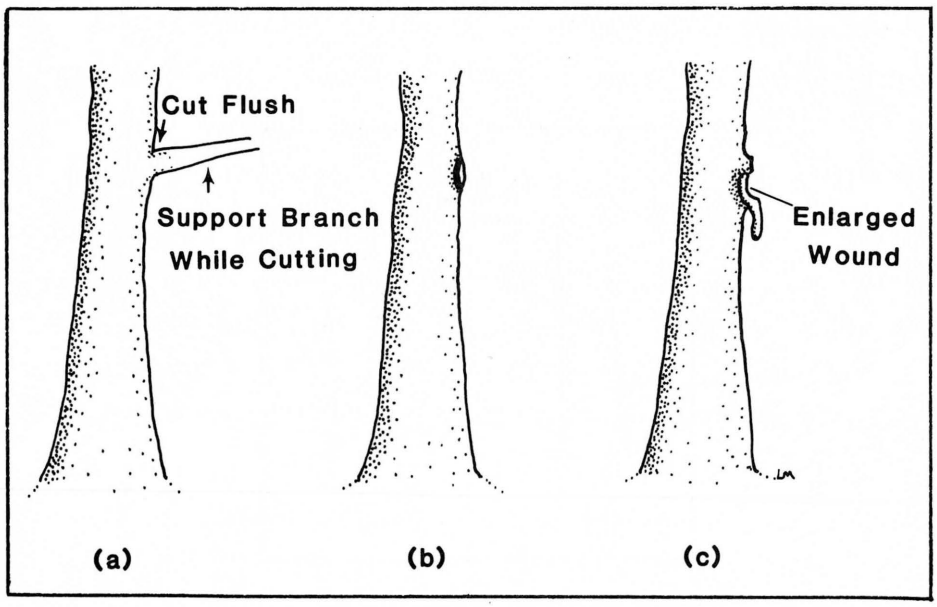


Figure 33 Pruning live branches: *(a)* Hardwood branches less than one inch in diameter and all sizes of conifer branches may be pruned by flush cutting. Branch weight should be supported until the cut is complete to avoid tearing bark below the cut and enlarging the wound. *(b)* Correct pruning. *(c)* Poor pruning.

years. Have someone assist by standing back and directing the process with an artistic eye. Look for natural breaks in the crown that allow reshaping and new form. When topping several trees, remove tops at different heights and reshape for a pleasing, natural appearance (Figure 32).

Topping hardwoods is not recommended for a number of reasons. While conifers usually have only one stem to cut, hardwoods may have many. The remaining wounds left from topping may be large and horizontal to the ground. Moisture is trapped on these wounds providing excellent entry for decay. Even if no decay enters these wounds, the junction where new shoots form is weak. New shoots cannot be allowed to grow large. Thus once a hardwood is topped, it must be retopped periodically (Peace, 1962). Topping a hardwood will remove the top branches, but heavy side branches still remain. The result is a tree with poor appearance that may still be hazardous. When hardwood crown reduction is necessary, branches should be pruned in a carefully planned thinning operation to provide a natural and pleasing shape (Figure 31).

Pruning

Pruning is usually needed to remove live, low hanging branches, large hazardous dead branches, or branch stubs.

Dead limbs do not pose much hazard if they are of small diameter. The lack of foliage and moisture usually makes the limb light and of little hazard. Large dead limbs are more hazardous and should be pruned. The following rule of thumb will help in deciding whether a **dead** limb should be pruned, provided it would fall on some kind of target.

Prune conifer if:

- The limb has defects such as decay or cracks.
- The limb size is greater than 3 inches in diameter and 6 feet in length.
- The limb has a high probability of falling on people or property. For instance, a dead mistletoe broom hanging over a picnic table should be removed.

Prune hardwood if:

- The limb size exceeds 2 inches in diameter and 4 feet in length.
- The limb has a high probability of falling on people or property.

(Hadfield and Filip, 1980)

However, all dead branches should be removed when practical to promote rapid closure and minimize the entrance of microorganisms. The following guidelines should be followed when pruning:

Live Branches—

1. For branches less than one-inch in diameter cut branch flush with tree. Be careful not to tear bark below branch by supporting the branch while cut is being made until completely severed (Figure 33).
2. For hardwood branches greater than one-inch in diameter undercutting is necessary to prevent tearing of bark below the branch. Make an undercut one-third of the diameter through the branch about one foot from the trunk. The next cut should be made from the top of the branch a few inches further from the trunk than the undercut. Flush cut the remaining stub, supporting the stub till completely severed (Figure 34).
3. Most conifer branches greater than one-inch in diameter can be flush cut without the undercut.

Dead Branches—Branches that have been dead for several years usually form callus tissue around the branch stub. These branches should be severed at the point where the dead branch and callus meet. Do not cut into callus; it only enlarges the wound and increases the chance of decay (Figure 35) (Tattar, 1978).

In general, speed of correction is not critical except in cases of root rot or leaning trees with loosened roots. With the other defects or mortality the manager has some leeway as to when corrective measures should be carried out during the inspection cycle.

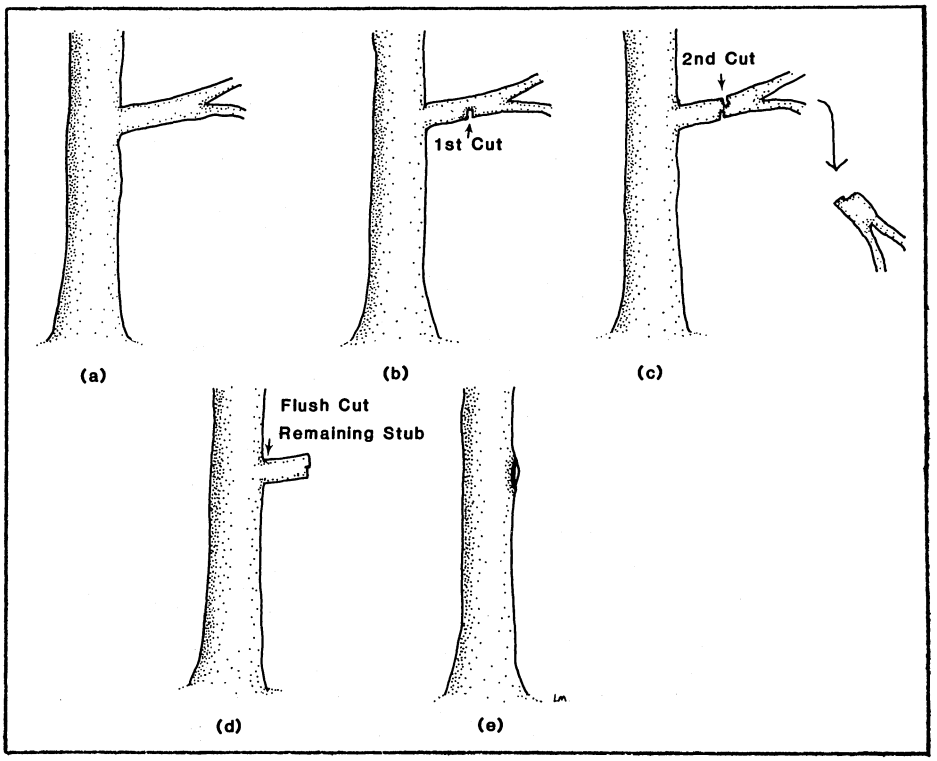


Figure 34 Pruning live branches: For hardwood branches larger than one inch in diameter *(a)* undercutting may be necessary to avoid tearing the bark.

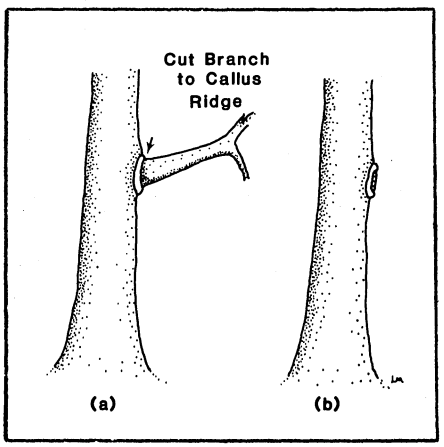


Figure 35 Pruning dead branches: *(a)* Live callus tissue around branch should not be cut when pruning because wound will be enlarged. *(b)* Correct.

Wound Treatment

Many hazard trees are caused by man's activities. Many of the defects are due to wounding and the subsequent invasion of microorganisms and decay fungi. Most wounds can be minimized or completely prevented.

Trees are wounded by many agents such as woodpeckers, beaver, deer, and other animals. Broken attached branch stubs are natural wounds. They open the tree to attack by microorganisms. Fire scars damage the bark, also providing an entrance.

The main causes of tree damage in recreation areas are their human occupants. In the construction stage of the park, trees are wounded by machinery such as bulldozers (Figure 36). Trees are easily wounded in thinning operations (Figure 37). During maintenance, wounds are caused by mowers and improper pruning techniques. Trees can also be damaged by careless use of herbicides. Recreation users inflict many wounds by pounding nails into trees, gathering and chopping firewood, damaging trees with vehicles, and engraving in the bark. The list can go on and on.

The prevention of wounding cannot be over stressed because they are pathways for bacteria and fungi which begin the decay process (Figure 38) (*Tree Decay An Expanded Concept* by Alex L. Shigo, 1979, gives an excellent account of the decay process. See Suggested References.) By preventing wounding or promoting rapid closure of wounds, decay problems will be kept at a minimum. When wounds are present, they should be treated in the following way:

New Wounds—Remove loose bark over wound. Remove tight bark around wound outward to healthy bark tissue. Shape wound into a vertical ellipse or eye shape which allows callus formation and wound closure in minimum time (Figures 39 and 40). Wound dressings are not necessary because they do not contribute to healing (Felix and Shigo, 1977).

Old Wounds—An old wound usually forms callus, but it often goes unobserved because of loose bark around and over it. Loose bark should be removed until the callus layer is found. Do not cut into the callus layer. This only enlarges the wound. If the callus layer is not continuous around the wound, cut dead bark away to living tissue similar to the method used for new wounds (Figure 40) (Tattar, 1978).

Figure 36 Wounds caused by bulldozer during road construction. Tree may be hazardous 20 years later.

Figure 37 Wounds made during thinning operation. May case harden and cause minimal decay but should be watched.

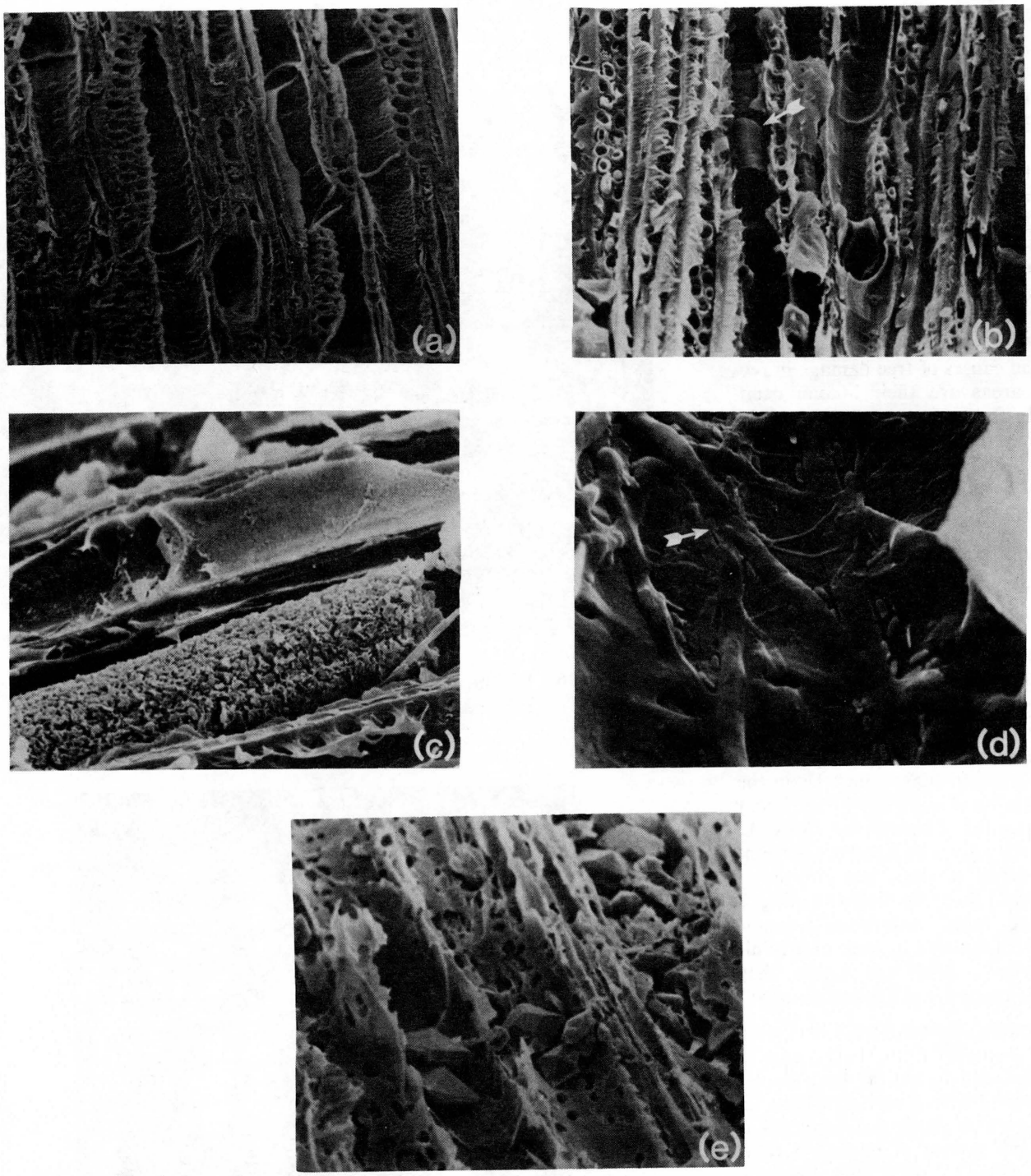


Figure 38 Scanning electron micrographs of apple wood showing reaction to wounding and the succession of microorganisms into the wound: *(a)* Healthy wood; *(b)* tree reaction to wounding — wood becomes discolored, vessel cells plug preventing the spread of microorganisms; *(c)* yeasts and bacteria break down vessel plugs; *(d)* wood rotting fungus mycelium follows yeasts and bacteria; and *(e)* advanced decayed wood. (Scanning electron micrographs by Robert A.Blanchette, Department of Plant Pathology, University of Minnesota.)

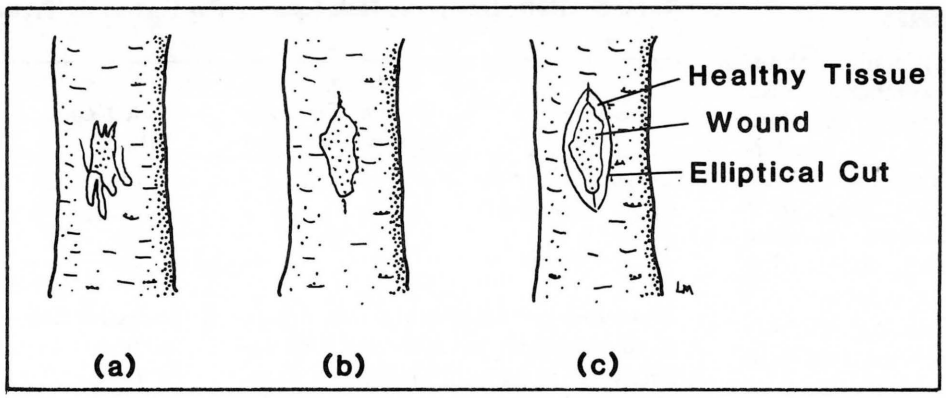


Figure 39 *(a)* New wounds on trunk or roots. *(b)* remove loose bark cutting back to healthy tissue. *(c)* Shape the wound into a vertical lens or eye shape.

Figure 40 Shaped wound made six years earlier has almost healed. The eye shaped cut promoted rapid closure.

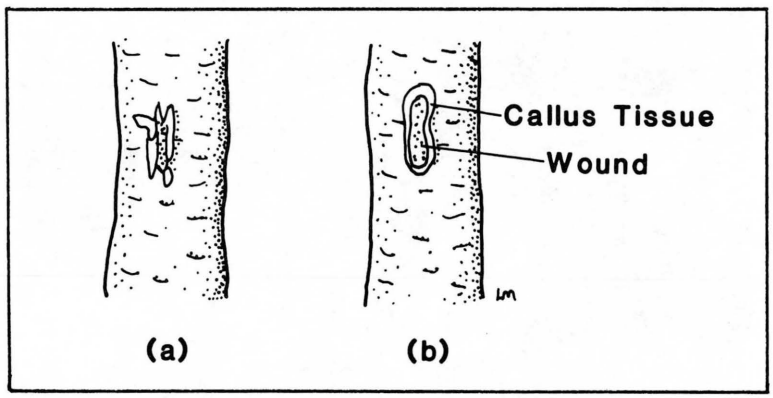


Figure 41 *(a)* Old wounds on trunk or roots. *(b)* Remove dead and loose bark back to callus tissue. Do not cut into calluses; this enlarges the wound. If callus is absent, remove bark to healthy tissue as in Figure 39.

Other Treatments

In the long run, overall stand maintenance will decrease the number of defective trees in the future and will stimulate tree vigor. Treatments can include fertilization, stump treatment for root rot, mulching for preventing compaction and excessive temperature, planting damage resistant species, and fencing exclosures to protect new plantings.

Fertilization—Fertilizing will not only stimulate growth, but it helps trees resist adverse effects of drought, disease, poor soil quality, or root injury.

Fertilizer should be applied in evenly spaced holes, drilled within the dripline of the tree. Use a balanced fertilizer such as 10-10-10 or 5-10-10. (The numbers refer to the percent available nitrogen, phosphorus, and potassium respectively and their ratio in the fertilizer.) Refer to Table 5 for fertilizer rate, hole depth and distance between holes. Fill the last three to four inches of hole with loose soil (Canadian Forestry Service, 1974).

Table 5 Rate, Depth and Hole Spacing For Fertilizing Trees

Tree	Fertilizer Rate (Pounds Per Inch of Tree Diameter)	Hole Depth (Inches)	Distance Between Holes (Inches)
Large Hardwoods	3	15–18	18
Small Hardwoods	1–2	15–18	18
Conifers	½–1	12	36

Root Rot—Treat freshly cut western hemlock stumps in recreation sites with borax to prevent invasion by *Fomes annosus*. This will in turn prevent infection of nearby remaining trees through root grafts with the stump. When other types of root rot are present, stump removal should be considered. These treatments will reduce the amount of root rot in the area.

Soil Compaction—Prevent soil compaction by spreading wood chips or bark over roots or along trails. Erecting barriers to change use patterns also reduces soil compaction damage.

Excessive Soil Temperature—Excessive soil temperatures caused by the removal of too much undergrowth can be prevented by mulching with bark or wood chips. This combined with fertilization will protect the tree from root damage.

Replanting—Replant with damage resistant species or a species mix. This will favor a stronger future generation of trees.

New plantings can be protected from human and machinery damage by enclosing them within barriers, such as fencing. This has been done with good results and is well worth the effort (Figure 42).

Figure 42 Young pine trees protected from the effects of wind and soil compaction by fencing enclosures in a high use area (Fort Casey State Park).

Planning

Careful planning of sites can also reduce hazards in recreation areas. Health and age of the trees should be considered when deciding where to locate campsites, picnic areas, etc. For instance, campsites and playgrounds should not be placed under or near old growth trees; the chance of trees or tree parts falling on unwary people is too great. However, sites designated for picnicking or trails could be put under old growth trees.

Do not place campsites near areas of bulldozer damage (compacted soil, root and trunk wounds, etc.). Better yet, prevent bulldozer and other machinery damage altogether through personnel training, close supervision, and clearly worded specifications in contracts. If damage to trees is prevented now, future hazard trees will be prevented (Figure 43).

With the growing demand for recreational facilities, there might be pressure to open new recreation areas quickly. However, sound long-term planning is necessary in areas where heavy construction or vegetation change occurs.

After considerable vegetation or tree removal, it is wise to allow the forest to stabilize several years if possible before permitting public use. This will allow the remaining trees to adjust to changed wind pressures, increased solar radiation, and soil temperature. This requires many years of careful advance planning, but is important to insure a safe recreation area.

Figure 43 Bulldozer activity caused damage to this old growth Douglas fir. Soil was removed from one side of the tree, roots were cut, and soil compacted. Branches on the affected side soon died creating severe hazard to campers (Lake Merrill near Cougar).

APPENDIX I

Recreation Site Hazard Tree Record

Recreation Site Hazard Tree Record

1. Site Name
2. Inspection Date
3. Personnel

4. Tree No.	5. Species	6. Age	7. Height	8. DBH	9. Location			10. Part of Tree Affected	11. Defect Description	12. Target Description	13. Influencing Factors	14. Boring Results	15. Hazard Rating	16. Recommended Action	17. Date Action Taken and Initials
					Ref. Pt.	Azimuth	Distance								

Recreation Site Hazard Tree Record

1. **Site Name**
2. **Inspection Date**
3. **Personnel**
4. **Tree No.**—Number defective trees in order of examination for quick reference.
5. **Tree Species**
6. **Age**
7. **Height**
8. **DBH**
9. **Location**—Determine azimuth and distance from fixed reference point.
10. **Part of tree affected**—Branches; Bole; Butt; Roots
11. **Defect description**—snag, dead top, thinning, pale or red crown, shortened leader, dead or broken branches, dwarf mistletoe, defoliating insects, split crotch, weak fork, frost crack, lightning scar, fruiting bodies (conks), punk knots, wound, canker, bark insects, dead bark, hollow, resin soaked soil around trunk (resinosus), wet looking bark near base, loosened roots, (leaning tree), rotted roots, fungus mycelium on roots, root insects, other downed trees in area, other _____ (note size of defect)
12. **Target description**—picnic site, campsite, restroom, interpretive sign, viewpoint, monument, playground, boat launch, parking lot, building other _____
13. **Influencing factors**—fire logging, flooding, poor drainage, construction blowdown, lightning, drought, winter drying, snow, ice, freeze, chemical injury, poor rooting base, prevailing wind azimuth, other _____
14. **Boring results**—If tree is drilled to check for amount of sound wood, note here _____
15. **Hazard Rating**
    (a) Chance of imminent tree failure (Rate tree 1-4)
    1 = low failure probability
    2 = moderate failure probability
    3 = high failure probability
    Add an extra point if tree exhibits other defects in addition to structural problems, i.e. a lean.
    (b) Chance of doing extensive damage to target (Rate 1-3)
    1 = low damage
    2 = moderate damage
    3 = extensive damage
    (c) The sum of (a) and (b) is the hazard rating for the tree. Use this rating in the following table when deciding on corrective action:

Rating	Degree of Hazard	Action
6-7	High	Remove tree or target
4-5	Moderate	Monitor tree for another year or remove tree or target
2-3	Low	Monitor—do not remove

16. **Recommended Action** — Remove tree, remove target, prune top, other _____.
17. **Date action taken**

Appendix II

Recommended Equipment

Binoculars—used to check the top of the tree for defects.

Hatchet or Axe—used to check for root rot or to tap tree to judge for hollowness.

Cordless Drill or Increment Borer—used for boring into tree to test for amount of sound wood. The most reliable cordless drill models have ⅜" chuck size with extra interchangeable battery packs (at least 3). Use 3/32" to ⅛" diameter by 8-12" long aircraft bits. The bits must have full fluting to carry wood chips out when drilling deep into pitchy, green trees.

Diameter Tape—used to measure DBH of tree.

Clinometer or Abney Level—used to measure height of tree.

Tape Measure and Compass—used to locate tree for future inspection.

Camera—for defective tree documentation.

Hazard Tree Report Forms.

Appendix III

Glossary

Azimuth—Compass reading in degrees; with north point at 0° going clockwise to 359°

Brace—A form of tree surgery in which rods are installed to give additional support to a tree suffering from a split crotch or internal decay.

Brooms—Abnormal clustering of branches caused by dwarf mistletoe and other diseases.

Cable—A form of tree surgery in which the limbs of a heavy, multi-branched tree or split crotch are supported together by attaching eyebolts to the branches and cabling the eyebolts.

Callus—Tissue produced in response to injury that grows over or closes a wound.

Canker—A localized infection on a tree; usually swollen or shrunken.

Chlorosis—Yellowing of foliage.

Conk—Shelflike fruiting body of many decay fungi.

DBH—Diameter at breast height (4½ ft.)

Defect—Any structural fault or disease condition that would render a tree unsafe.

Drip Line—Circle described by the outermost branches of a tree projected to the ground.

Frass—Dust and excrement left by insects boring into trees.

Fruiting Body—A reproductive fungal structure that produces spores, ranging in form from small microscopic bodies to large mushrooms and conks.

Gills—Platelike spore-bearing structures present on the underside of some mushrooms.

Hazard Tree—Any tree in close proximity to people or property with a defect or group of defects that could render it unsafe.

Hypha (pl. phae)—Vegetative fungal structure; microscopic threadlike strand.

Leader—Growing tip of a tree.

Mycelium—Masses of hyphae resembling tangled thread.

Pores—Minute round holes or pores present on the underside of fruiting bodies of many decay fungi from which spores are discharged.

Punk Knots—Rotten swollen knots containing fungus mycelium, often associated with a particular decay fungus, *Phellinus pini.*

Resinosus—Oozing of resin on the exterior of a tree as a result of wounding or root rot.

Rhizomorphs—Threadlike bundles of hyphae, often many feet long which penetrate soil and roots (Armillaria root rot).

Setal Hyphae—Short, bristly cinnamon-colored specialized hyphae of laminated root rot; a key identification aid.

Signs—Structures and products of the causal organism—fungus fruiting bodies, vegetative fungal structures, dwarf mistletoe, spores, etc.

Symptoms—The visible expression of the diseased plant by color change, growth rate reduction, wilting, heavy cone crop, resin oozing, etc.

Target—Person or property endangered by a defective tree.

Tree Failure—Tree or portion of a tree that collapses as a result of some structural weakness such as root rot, large dead branches, etc.

Undermined Roots—Roots exposed by agents such as erosion or flooding, leaving a poor foundation for the tree.

Volunteer Top—A lateral branch that becomes the top after the leader is killed.

Literature Cited

Canadian Forestry Service 1974. Fact sheet—*Planting shade trees.* Canadian For. Assoc. K1A OH3, Ottawa, Ontario.

Fairbridge, R.W. 1967. *The Encyclopedia of atmospheric sciences and astrology.* NY: Reinhold.

Felix, R. and A. L. Shigo 1977. *Rots and Rods,* J. of Arboriculture 3(10): 187-190.

Furniss, R.L. and V.M. Carolin 1977. *Western forest insects.* USDA For. Serv. Misc. pub. 1339. Washington, DC: U.S. GPO.

Gaidula, P. 1973. Training needs for field personnel in detection, evaluation and control of tree hazards in forested recreation areas. In *Proceedings of the 21st Western International Forest Disease Work Conference.* Estes Park, CO.

Hadfield, J.S. and G.M. Filip 1980. *Watch Out! Your favorite tree may kill you! A guide for recognizing and reducing tree hazards in forest recreation sites in the Pacific Northwest.* USDA For. Serv. PNW For. & Range Exp. Sta. In publication. Portland, OR.

Handy, Nixon 1980. Recreational resource management from a legal perspective. Paper presented at the University of Victoria.Victoria, B.C. Canada.

Handy, Nixon 1980. Personal communication. WA State Dept. of Nat. Res. Attorney General's Office. Olympia, WA.

Hawksworth, F.G. 1977. *6-class dwarf mistletoe rating system.* USDA For. Serv. RM For. & Range, Exp. Sta. Gen. tech. rpt. RM-48.Fort Collins, CO.

Lightle, P.C. and F.G. Hawksworth 1973. *Control of dwarf mistletoe in a heavily used ponderosa pine recreation forest: Grand Canyon, Arizona.* USDA For. Serv. RM For. & Range Exp. Sta. Gen. tech. rpt. RM-106. Fort Collins, CO.

Menefee, C. 1973. The legal implications of hazards from tree disease and related factors in recreational areas. In *Proceedings of the 21st Western International Forest Disease Work Conference.* Estes Park, CO.

Peace, T.R. 1962. *Pathology of trees and shrubs.* Oxford: Clarendon Press.

Russell, K.W., J.H. Thompson, J.C. Stewart and C.H. Driver 1973. *Evaluation of chemicals to control infection of stumps by* Fomes annosus *in precommercially thinned western hemlock stands.* WA State Dept. of Nat. Res. DNR report no. 33. Olympia, WA.

Tattar, Terry A. 1978. *Diseases of shade trees.* NY: Academic Press.

Wagener, Willis W. 1963. *Judging hazard from native trees in California recreation areas: a guide for professional foresters.* USDA For. Serv. PSW For. & Range Exp. Sta. res. paper PSW-1. Berkeley, CA.

Suggested References

Davidson, R.M. and R.S. Byther 1980. *Construction damage to trees on homesites.* EM 4551 Coop. Ext. WA State Univ., Pullman, WA.

Hadfield, J.S. 1980. *A guide to estimate failure probabilities of trees with defects.* USDA For. Serv. PNW For. & Range Exp. Sta. In publication. Portland, OR.

Hadfield, J.S. and D.W. Johnson 1977. *Laminated root rot, a guide for reducing and preventing losses in Oregon and Washington forests.* USDA For. Serv. PNW For. & Range Exp. Sta. Portland, OR.

Paine, Lee A. 1971. *Accident hazard evaluation and control decisions on forested recreation sites.* USDA For. Serv. PSW For. & Range Exp. Sta. res. paper PSW-68. Berkeley, CA.

Shigo, Alex L. 1979. *Tree decay: an expanded concept.* USDA For. Serv. Agric. inf. bull. no. 419. Washington, DC: U.S. GPO.

Shigo, Alex L. and Harold G. Marx 1975. *Compartmentalization of decay in trees (CODIT).* USDA For. Serv. Agric. inf. bull. no. 405. Washington, DC: U.S. GPO.

Shortle, W.C. 1979. *Tree Care: a new look.* J. of Arboriculture 5(12): 281-284.

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